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The Journal of Orthopædic Surgery

# BACKACHE AND ANATOMICAL VARIATIONS OF THE LUMBO-SACRAL REGION

ARCHER O'REILLY, A. B., M. D. ST. LOUIS

Goldthwait first emphasized the role of the sacro-iliac joint as a cause of backache; later the importance of the transverse process of the fifth lumbar and other anatomical variations has been noted.

Our knowledge of the bony structures in lumbo-sacral regions is still far from complete. Text book descriptions of this region are meagre. In the last few years, however, quite an extensive literature has developed, but this deals mostly with individual cases and with the question of sacro-iliac displacement.

In studying the X-ray plates of individual cases one is impressed with the anatomical variations that one sees. In order to learn whether these variations were as common as they seemed, I have undertaken this study.

X-ray plates of three hundred patients with backache were examined. Tracings were made from one hundred and ninety-nine. The majority of the cases were those seen in the Dispensary of the Washington University Medical School. A few were private patients. None of the plates studied was selected, so that the plates represent the general run of cases seen in the Clinic. The ages and occupations were tabulated in 257 cases. There were 163 men and 94 women. The ages were from 17 to 70, the greatest number occurring between 31 and 50 years in men and between 21 and 30 and 41 to 50 in women. (Table I.) There were 65 different occupations. Housewife was most frequent in women; miner and laborer the most common in men. (Table II.)

Tracings were made of the X-ray plate in 199 cases, and these were studied for variation in the sacro-iliac joints, the transverse processes of the fifth lumbar, and other changes.

These tracings could be divided into three definite types. (Fig. 1.) In Type I the sacrum is fairly high between the ilia. It is fairly broad and the upper border extends to, or a little beyond the line of the iliac crests, before it curves to form the line of the sacro-iliac joint. The crests of the ilia curve at an angle of about 45°. The distance between the posterior portion of the crest and the line of the sacro-iliac is fairly broad. For the remainder of my paper, I shall, for brevity, refer to this as the sacro-iliac. This is a mixed type and is found in both males (57)

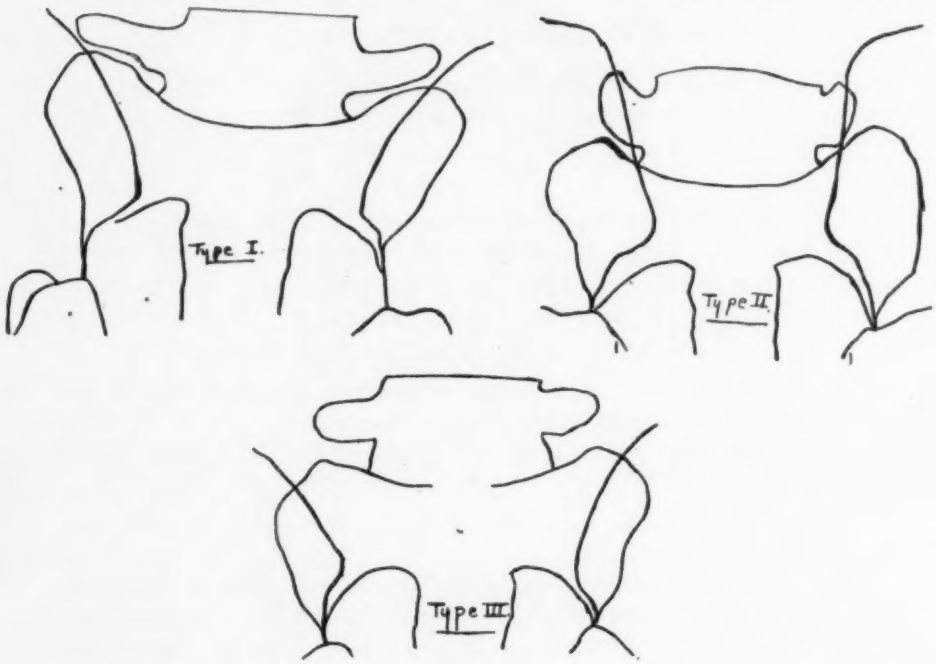


FIG. 1.

and females (29). It is also a transitional type, as some of the cases show characteristics of the other types. Fig. 2. (Table 3.)

Type II (Fig. 1) is very distinctive. The crests are almost vertical. The outlines of the posterior spines of the ilia are sharp and angular. The general impression is that the sacrum is narrow and is set low between the crests. The line of the sacro-iliac is well beyond the shadow of the crests and the distance has a tendency to asymmetry. The sacro-iliac may be

either broad or shallow. This is almost exclusively a male type. (Fig. 3)

Type III somewhat resembles Type I, but the sacrum is wider; the curve of the sacro-iliac begins before it crosses the shadow of the ilium, so that there is a distinct notch, as shown in the diagram. In Type III, the shadow of the sacro-iliac is more shallow than in Types I and II. This is a female type; there were 35 women and only 5 men. (Fig. 4)

FIG. 2.

All these types show some variations and many irregularities. These may be seen in the illustrations. In all cases four measurements were made: (a) The distance between the points where the shadow of the crests of the ilia crossed the shadow of the ala. (b) The distance between the sacro-iliacs. (c) The length of the right sacro-iliac from point a. on the right side to the lower end of the sacro-iliac; (d) The same for the left sacro-iliac. Line (a) was selected as it seemed to give a more constant point. It does not give the accurate measurement of the width of the upper portion of the sacrum; it is fairly constant, however, and is of value in comparing the measurements in each case.

These measurements showed marked variations running from 0.1 cm. to 3.0. (Table 4) Table 4 shows the variations in width of Types I, II and III.

In the sacro-iliac measurements there were variations in the with between the right and the left from 0.1 cm. to 1.2 cm. (Table 5.)

I do not believe that these measurements prove anything, except that there is considerable variation on the two sides. Some of this irregularity might be due to variation in the position of the tube, but the X-rays were all taken in a standard position with the tube at a point midway between the anterior superior spines of the ilium.

The study of the transverse processes of the fifth lumbar was most interesting, as these showed the greatest variety in size and

FIG. 3.

FIG. 4.

shape. They might be roughly divided into three general types, as shown in Fig. 6,—the straight type, (1) the bulbous type (2) and the large fan-shaped type (3). (Fig. 5)

Figure 6 shows the tracings of various types of transverse processes given in the order of their frequency. The number at the bottom shows the number of times each occurred. As there were 199 cases there were 398 possibilities. Number 1 might be called the normal process. Number 2 is a very interesting type. As the tracing shows, in a number of cases the lower border seems to conform to the shape of the iliac crest, suggesting that

it is in close proximity to the crest and that its shape has been modified by it. As can be seen, the others are modifications of the three types.

Figures 7 and 8 show tracings of twenty-four types which occurred less than ten times. Some are similar, but each shows some difference, and they are shown to emphasize the great number of variations and varieties seen.

Fig. 9 shows bifid process.

In only 53 of the 199 cases were the processes alike on both sides, and most of these showed a very definite asymmetry. (Table 6)

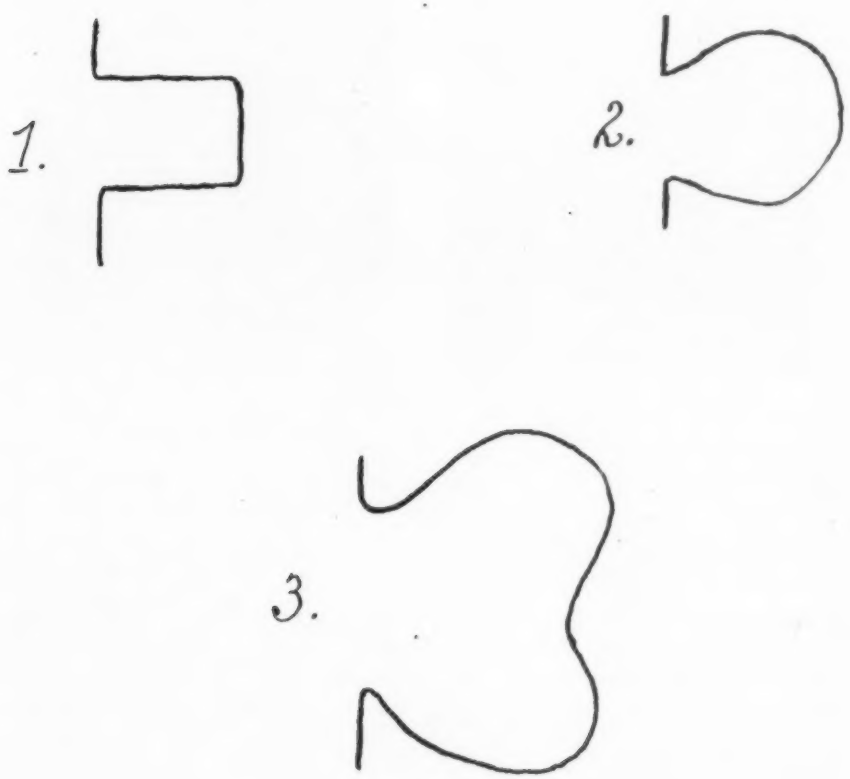


FIG. 5.

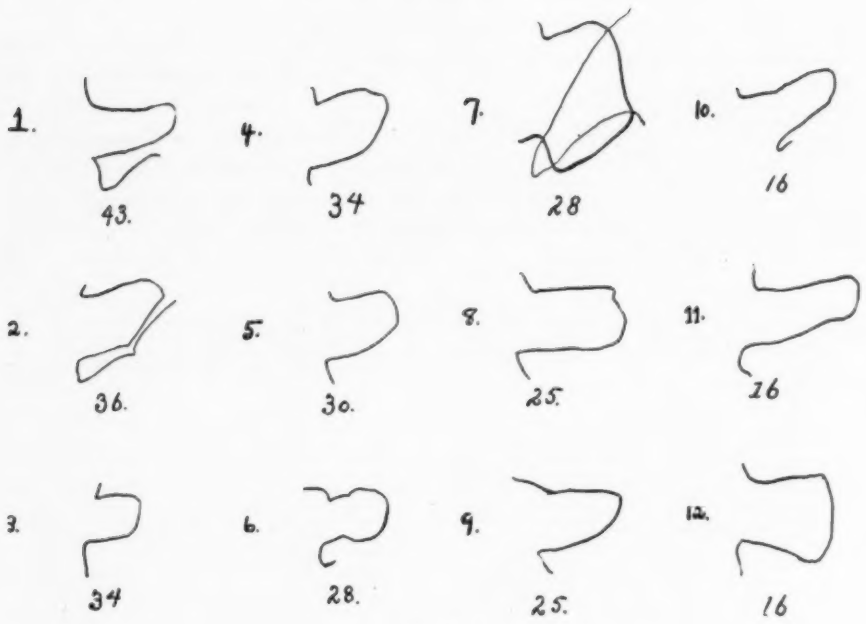
1.
43.
4.
34
7.
28
10.
16
2.
36.
5.
30.
8.
25.
11.
16
3.
34
6.
28.
9.
25.
12.
16

FIG. 6.

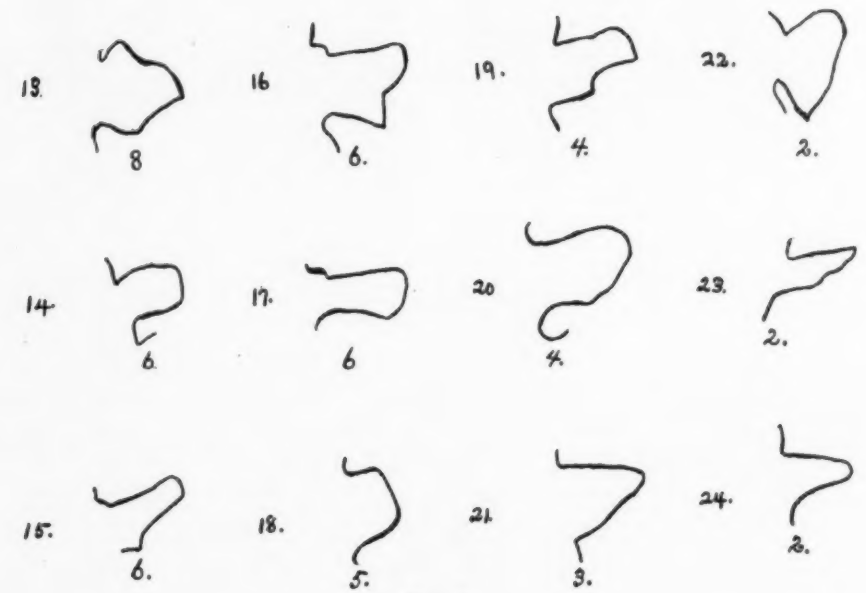
13.
8
16
6.
19.
4.
22.
2.
14
6
17.
6
20
4.
23.
2.
15.
6.
18.
5.
21
3.
24.
3.

FIG. 7.

96 of the transverse processes pointed upward from a few degrees to 55 degrees; forty-four of these on the right and 52 on the left, 78 in males and 18 in females. It has been suggested that variations in the transverse processes might be due to posture and occupation. It is possible that the angle of the transverse processes is due to muscle action. It is interesting to note that in Type III, four spinous processes pointed down slightly, 3 on right and one on left.

Long transverse processes, (Fig. 3)—i. e. those whose shadow overlapped that of the crest, and potentially might impinge on the crest of the ilium,—were rather common; the greater number was in Type II, Table 7.

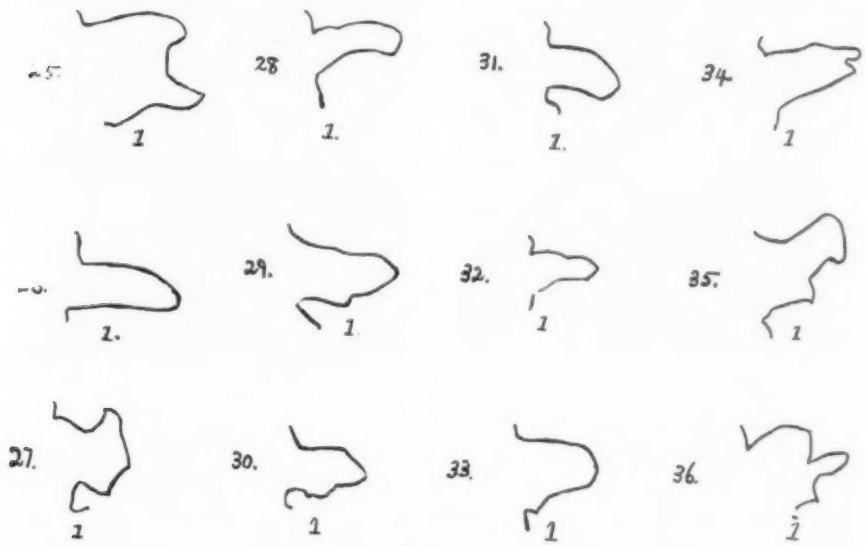


FIG. 8.

Long transverse processes are much more common in men than in women. This would probably be explained by the fact that in men the transverse processes are large and consequently more apt to overlap than in women.

The large fan-shaped or fishtail process (Fig. 10) which overlaps the ilium and frequently is fused with the sacrum is not uncommon. 8½ per cent showed this variation on one or both sides. (Fig. II.) There were seventeen cases of this type,

ten males and seven females. (Table 8.) All but two were of Type II.

Bifurcation of the first sacral (Figs. 12-13) is a fairly common condition. In three hundred examined, there were nineteen cases,—about six per cent. Four were in Type 1,—all males. In Type II there were 9 males and one female, and in Type III, there were five females. The proportion of males to females is about the same as in the total number of cases seen.

FIG. 9.

FIG. 10.

Spondylolisthesis seems to be more common than is usually supposed, and is probably overlooked in a good many cases. In 300 cases there were 19 suggestive of this condition. (Fig. 14) Four were males, Type I, and two females. In Type III, one male and one female. In all, there were 13 males and 6 females. As would be expected, occupation seems to have a definite role in causing this condition. There were four miners, two foundry workers, one laborer, one farmer, one auto repairer.

In no case was there a definite separation of the sacro-iliac joint. In several, the joint seemed wider on one side than on the other, but this was probably due to the position in which the X-ray was taken.

FIG. 11.

FIG. 12.

FIG. 13.

FIG. 14.

Summary:—The study of these plates seems to show that the sacra and sacro-iliacs may be divided into three types. Type 1 is seen in both males and female.

Type II is distinctly a male type and Type III distinctly female.

In Types I and II, over-lapping transverse processes are common. It is impossible to tell, however, from the X-ray whether this is merely an overlapping of the shadows or whether there is actual contact. It seems probable that where contact takes place, it is more likely to occur in Type II. Type II also seems to show more irregularities in the shape of the transverse processes, and in the structure of the sacrum and shape of the sacro-iliacs.

The measurements, not of great accuracy for comparative use owing to the varying conditions, but constant in each case, seemed to show a very definite and, in many cases, a marked asymmetry.

The size and shape of the transverse processes varied greatly and in the majority of cases were quite asymmetrical, of distinctly different types. Even in those cases where they were alike they showed distinct differences, and in a large number of cases they pointed upward to a greater or less extent.

Large fan-shaped transverse processes are rather common; when single they seemed to occur more frequently on the left side. They are much more common in the second type.

Bifurcation of the first sacral spinous process is fairly frequent, 6% of the cases showing this defect.

Spondylolisthesis of varying degree is probably more common than usually supposed, also rotation and slipping between the lumbar and sacral articulations.

There are also rarer cases that show congenital malformations.

In conclusion, there seems to be no one type that might be called normal. There are many variations in the lumbo-sacral region. Asymmetry is the predominating feature, and, at any rate from the X-ray, it is impossible to say which special combination of types is normal.

## TABLE 1.

| Ages | Male | Female | Total |
|---|---|---|---|
| 10 to 20 | 4 | 7 | 11 |
| 21 to 30 | 25 | 26 | 51 |
| 31 to 40 | 52 | 25 | 77 |
| 41 to 50 | 57 | 26 | 83 |
| 51 to 60 | 18 | 7 | 25 |
| 61 and over | 7 | 3 | 10 |
| Total | 163 | 94 | 257 |

## TABEL 2.—OCCUPATIONS

| | | | |
|---|---|---|---|
| Housewife | 40 | Carpenter | 7 |
| Laborer | 27 | Cook | 6 |
| Miner | 24 | Blacksmith | 5 |
| None | 22 | Foundry | 5 |
| Factory | 10 | Farmer | 5 |
| Teamster | 8 | | |

The remainder divided between 54 other types of occupation.

## TABLE 3.—DISTRIBUTION BY TYPES

### TYPE I.

| | |
|---|---|
| Total number of men | 51 |
| Long transverse processes: Right, 5; left, 5; both | 10 |
| Total number of women | 29 |
| Long transverse processes: Right, 2; left, 3; both | 0 |

### TYPE II.

| | |
|---|---|
| Total number of men | 57 |
| Overlapping transverse processes: Right, 13; left, 8; both | 18 |
| Total number of women | 2 |
| Overlapping transverse processes: Right, 1; left, 0; both | 0 |

### TYPE III.

| | |
|---|---|
| Total number of men | 5 |
| Overlapping transverse processes: Right, 0; left, 0; both | 0 |
| Total number of women | 35 |
| Overlapping transverse processes: Right, 0; left, 0; both | 0 |

Cases with large fan shaped processes are not included in this table.

## TABLE 4.—*Sacral* MEASUREMENTS

The figures represent the differences in width. When placed in line A they indicate that the upper measurement was greater than the lower, and the reverse when under B, when in line S the measurements were the same. Measurements are in centimeters.

### TYPE I.

| Case No. | 1 | 2 | 3 | 4 | 5 | 6 | 7 | 8 | 9 | 10 | 11 | 12 | 13 | 14 | 15 |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| A. | .2 | .... | 1.5 | .2 | .... | .6 | .... | .1 | .... | .2 | 2.0 | 1.3 | .2 | .... | .... |
| B. | .... | 1.2 | .... | .... | .... | .... | .1 | .... | .... | .... | .... | .... | .... | 1.6 | 2.0 |
| S. | .... | .... | .... | .... | / | .... | .... | .... | / | .... | .... | .... | .... | .... | .... |

| Case No. | 16 | 17 | 18 | 19 | 20 | 41 | 42 | 43 | 44 | 45 | 46 | 47 | 48 | 49 | 50 |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| A. | .... | .... | 1.8 | 1.8 | .... | .... | .... | .... | .... | .... | .... | .... | .... | .... | .6 |
| B. | .6 | 2.0 | .... | .... | .4 | .5 | .5 | 2.5 | 2.0 | 1.5 | 3.5 | 1.3 | 2.0 | .8 | .... |

| Case No. | 70 | 71 | 72 | 73 | 74 | 75 | 76 | 77 | 78 | 79 | Average |
|---|---|---|---|---|---|---|---|---|---|---|---|
| A. | 1.5 | .1 | .5 | 2.0 | .3 | 3.0 | .2 | 3.0 | 1.4 | 2.1 | 0.91 |
| B. | .... | .... | .... | .... | .... | .... | .... | .... | .... | .... | 1.4 |
| S. | .... | .... | .... | .... | .... | .... | .... | .... | .... | .... | .2 |

### TYPE II.

| Case No. | 81 | 82 | 83 | 84 | 85 | 86 | 87 | 95 | 89 | 90 | 101 | 102 | 103 | 104 | 105 |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| A. | .6 | .3 | .6 | .5 | .... | 1.5 | .... | 1.0 | .5 | .... | .... | 1.0 | .... | .... | .... |
| B. | .... | .... | .... | .... | .4 | .... | .3 | .... | .... | .... | 1.3 | .... | 2.6 | 1.1 | .9 |
| S. | .... | .... | .... | .... | .... | .... | .... | .... | .... | / | .... | .... | .... | .... | .... |

| Case No. | 106 | 107 | 108 | 109 | 110 | 126 | 127 | 128 | 129 | 120 | 121 | 132 | 133 | 134 |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| A. | .... | .... | .... | .... | .... | .... | .... | .... | .... | .... | .... | .... | .... | .... |
| B. | 1.1 | 2.3 | .8 | 1.5 | .9 | 2.2 | 2.3 | 1.1 | .3 | 3.7 | 1.0 | 1.2 | .9 | .8 |

| Case No. | 135 | 122 | 123 | Averages |
|---|---|---|---|---|
| A. | 1.1 | .... | .... | 0.78 |
| B. | .... | 1.3 | .3 | 1.2 |
| S. | .... | .... | .... | 1. |

TYPE III.

| Case No. | 138 | 139 | 140 | 142 | 143 | 144 | 145 | 146 | 147 | 148 | 155 | 156 | 157 |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| A. | .1 | .8 | 1.0 | 1.8 | 2.2 | 1.1 | .2 | 1.1 | 1.3 | 2.0 | 1.9 | .... | 3.1 |
| B. | .... | .... | .... | .... | .... | .... | .... | .... | .... | .... | .... | .... | .... |
| S. | .... | .... | .... | .... | .... | .... | .... | .... | .... | .... | .... | / | .... |

| Case No. | 158 | 159 | 169 | 170 | 171 | 172 | 173 | 174 | 175 | 176 | 177 | 178 | Average |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| A. | .2 | 1.9 | 1.0 | 2.0 | 2.3 | .... | 1.0 | .3 | .... | 2.3 | 1.8 | .6 | 1.35 |
| B. | .... | .... | .... | .... | .... | .3 | .... | .... | .... | .... | .... | .... | .3 |
| S. | .... | .... | .... | .... | .... | .... | .... | .... | / | .... | .... | .... | .2 |

## TABLE 5.—VARIATION IN VERTICAL DISTANCE OF SACRO-ILIACS BY TYPES

TYPE I.

| | | |
|---|---|---|
| Right longer in | 15 cases. | Average 0.38 c. m. |
| Left longer in | 13 cases. | Average 0.34 c. m. |
| Same in | 10 cases. | |

TYPE II.

| | | |
|---|---|---|
| Right longer in | 9 cases. | Average 0.55 c. m. |
| Left longer in | 17 cases. | Average 0.45 c. m. |
| Same in | 6 cases. | |

TYPE III.

| | | |
|---|---|---|
| Right longer in | 11 cases. | Average 0.39 c. m. |
| Left longer in | 9 cases. | Average 0.47 c. m. |
| Same in | 5 cases. | |

# TABLE VI. A. TYPE I

M. Male · T: Transverse Process Touches · Large Nos. rep. types of Trans. Processes in Fig.
F. Female · L: Transverse Process Laps. · A: Angle of Process Upward
B. Bifid 1st Sacral · S. Shallow Sacroiliac. · D: Angle of Process Down. } large angles shown in degrees

| R | L | R | L | R | L | R | L | R | L | R | L | R | L | R | L |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| 1 F | 1 T | 11 F | 1 | 21 F | 2 | 31 M L | 2. 20° | 41 M | 8 52° | 51 M A | 2. A. | 61 M | 4. T. | 71 M. | 11 |
| 2 F | 14. L | 12 F | 10. 28° | 22 F | 12 | 32 M T. | 2. | 42 M. | 8. 35° L. | 52 M. | 4 | 62 M A | 3. S. | 72 M A | 11 S. |
| 3 F | 25 L S | 13 F | 2 | 23 F | 14. | 33 M L. | 2 B 17° | 43 M. | 1 A L. | 53 M | 9 | 63 M | 11 B | 73 M A | 3 A. |
| 4 F | 5 15° | 14 F | 3. | 24 F | 8 T | 34 M | 12. 21° L | 44 M | 5. A L. | 54 M | 13. A | 64 M | 4. _ | 74 M | 11 |
| 5 F S | 15 S | 15 F | 2. | 25 F | 6. T. | 35 M | 5. 40° L | 45 M L | 3. A L. | 55 | 8 T 35° | 65 M | 4. 49° | 75 M | 13 |
| 6 F S | 1 | 16 F | 2. | 26 F | 6 | 36 M | 4 T | 46 M L | 4. L. | 56 M | 18. | 66 M | 11 | 76 M | 5. |
| 7 F | 3 | 17 F | 18 26° | 27 F | 10. 33° S | 37 M A | 11. A L. | 47 M L | 5 L. | 57 M | 11 | 67 M | 21 S | 77 M | 4 |
| 8 F | 2 | 18 | 5. | 28 F | 9 28° | 38 M | 12. L. | 48 M | X | 58 M | 4. T. | 68 M S | 18. S. | 78 F | 8 |
| 9 F X Not Shown | 3 | 19 F | 3. | 29 M L | 5 57° T | 39 M | 10 42° L | 49 M | 2. | 59 M | 4. | 69 M A | 6. A | 79 M | 8 |
| 10 F | 21 | 20 F | 1 | 30 M L. | 8 T 37° | 40 M A. | 8 A. L. | 50 M | 10 32° | 60 M | 5. T. | 70 M B | 1 A | 80 M | 3. A. |
| 16 | | 9 | | 4. 22° | | 8 | 8 | 10 40° | | 13. | | 2 | | 9 | |

# TABLE VI.b TYPE II.

| R | L | R | L | R | L | R | L | R | L |
|---|---|---|---|---|---|---|---|---|---|
| 4 | 9 S | 9 A | 5 | 6 40° | 3 L | 4 L | 5 L | 9 | 12 |
| 6 | 3 | 9 | 4 B. S | 5 A L | 6 S A. | 5. | 5. L | 6 T | 6 |
| 2 | 2. B. | 12 | 2 S. | 2. L | 4. B | 5 L | 6 L | 10 L | 10 33° L. |
| 14. | 27. | 6 L | 3. 51° T | 1 L | 6 A B | 17 L | 3. L | 12 | 15. |
| 19. | 3. A | 23. L | 1 57° S | 5 L | 10. L | 9 L | 9. A L | 6 | 10 33° |
| 2 | 2 | 6 L | 5 T. | 12 S L | 12. S L | 1 L | 1 23° L | 16 A | 3. A S |
| 16. S | 22. S | 1 A T | 1 A L. | 8 A L | 8 A L | 4. 40° L | 4. 40° L. | 9 | 4 S B |
| 1 S | 17. B. T | 5 L | 6 40° T | 1 L. | 4. L | 1 A T | 4 A T | 7 L | 3 51° |
| 22. S L | 5 S. | 4 L. | 5. S. | 2. L. | 6. L | 2 | 1 39° | 19 | 4. A |
| 8 | 8 A. T. | 2 A L | 5 | 8. A L | 5 55° L | 3 | 6 L. | | |
| 1 | 17. B. | 16 A. L | 10. | 12 L | 9. B L | 2 | 5 L | | |
| 8 | 4 | 2 T | 4. | 5 L | 12. L | 4. 41° T | 5. L. | | |

# TABLE VI. c.
## TYPE III

| R. | L. | R. | L. | R. | L. | R. | L. | R. | L. |
|---|---|---|---|---|---|---|---|---|---|
| 138. M. 4 S | 13. S.B | 142. F. 1 S | 18 S | 138 F. 12 | 12 | 148. F. X | X S | 178. F. 1. | 1. |
| 139. M. 18 A. | 18 A | 141. F. 2 | X | 139 F. 32 | 24. | 149. F. 2 | 2. | 179. F. 8 A. | 12. A. |
| 140. M. 28 | 11 A. | 150. F. 2 S. | 4. S. | 160 F. 4. S. | 3. | 170. F. 3 | 11 S. | 180 F. 19. S | 3. S. |
| 141 M. 17 | 1 B | 151. F. 3 | 6 S. | 161 F. 6 S. | 1 S | 171. F. 1 | 11 S | 181. F. S. 34. | 2. S.B |
| 142 M. 4 | 16 B. | 152. F. 9 D S | 4 S | 162 F. 1 D.S. | 2 S. | 172. F. 1 | 1. | 179 F. 6 S | Type I. 3 S.A |
| 143 M. 9 S | 2 S | 153. F. 29. | 18 | 163 F. 6 | 3 | 173 F. 26 | 1 | | |
| 144 F. 1 D | 1 D | 154. F. 1 D | 3 | 164 F. 32 | 23 | 174. F. 8 S. | 8 S. | | |
| 145 F. 4 A | 2. | 155. F. 4 B | 15. S. | 165 F. 11 | 24 | 175 F. 6 | 8 | | |
| 146 F. 1 | 3. | 156. F. 30 | 31 | 166 F. 9 | 9 | 176. F. 10.41 S | 13.36 S | | |
| 147 F. 9 | 6 | 157 3 S. | 3 S. | 167 F. 5. | 19. | 177. F. 6 | 6 | | |

# TABLE VI. d
## TYPE – Large fan shaped Transverse Process

| R. | L. | R. | L | R. | L | R. | L | R. | L. |
|---|---|---|---|---|---|---|---|---|---|
| 182. M. Type II T. 10. | 7. L | 186. M. 6 | Type II. 7 S.L | 190. M. 7 L | Type II. 7 S.L | 194. F. 7. S.L | Type I. 7. S.L | 198 F. 7 S.L | Type I. 7 S.L. |
| 183. M. Type II 35. L | 7. L | 187. M. 7 S.L | Type II. 7 L | 191. M. 7 L. | Type II. 7 L. | 195. F. 7 L. | Type II. 7 L. | | |
| 184. M. Type II 3. A.T | 7. L | 188. M. 7. S.L | Type II. 7. S.L | 192. F. 7 L | Type II. 36. S.T. | 196. F. 7. L. | Type II. 7. S.L. | | |
| 185 M. 9 A | Type II 7. L. | 189. M. 7 L. | Type II. 12. S.L | 193. F. 7 L. | Type II. 7. L. | 197 F. 7. S.L | Type II. 7. S.L | | |

## TABLE 7.—OVERLAPPING TRANSVERSE PROCESSES

| TYPE I | Right | Left | Both | Total |
|---|---|---|---|---|
| Men | 4 | 9 | 3 | 16 |
| Women | 2 | 2 | — | 4 |
| **TYPE IJ** | | | | |
| Men | 15 | 7 | 14 | 36 |
| Women | 1 | 0 | 0 | 1 |
| **TYPE III.** | | | | |
| Men | 0 | 0 | 0 | 0 |
| Women | 0 | 0 | 0 | 0 |

## TABLE 8.—LARGE FANSHAPED TRANSVERSE PROCESSES

| TYPE I. | Right | Left | Double |
|---|---|---|---|
| Men | 0 | 0 | 0 |
| Women | 0 | 0 | 2 |
| **TYPE II.** | | | |
| Men | 1 | 5 | 4 |
| Women | 1 | 0 | 4 |
| **TYPE III.** | | | |
| Men | 0 | 0 | 0 |
| Women | 0 | 0 | 0 |

# SOME ASPECTS OF THE MECHANISM OF THE HUMAN FOOT IN WALKING

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Much has been written about the human foot and its mechanism so that it would almost seem that there remains very little to be said in regard to the subject. Most of what has been said, however, deals with the foot as a static machine, and the fact that the foot is a contrivance especially adapted for locomotion has been obscured. The text books of anatomy speak of the arches of the foot, and the general public, deriving its impressions indirectly from this source, is much interested in the subject of "Fallen Arches."

While an arch is a perfectly suitable architectural arrangement for a building, a bridge, or any structure that remains fixed in the one spot, it is not the correct term to apply to a structure which gives support to a body in motion. It would almost seem self-evident that the analogous structure for a kinetic mechanism is a spring, and yet so far as I am aware, there is no reference in the literature to the springs of the foot. The only approach to the terminology with which I am acquainted is the denomination of the inferior calcaneo-scaphoid ligament as the "spring ligament" of the foot.

Interpretation of the mechanism of the foot by a study of the gait of the ordinary town-dweller is in many respects unsatisfactory. The use of foot gear from our earliest years has interfered with the normal development of the intrinsic musculature, and the comparatively small amount of walking which we are accustomed to do enables us to remain satisfied with feet which are hardly ever developed to their full capacity as organs of locomotion.

It is a truism that structure and function go hand in hand, and it is possible from a study of the anatomy of the foot to obtain a fairly accurate idea of the ideal aimed at in the structure of the foot, if the latter be looked upon as essentially a kinetic mechanism, not a static one. From the purely static standpoint, any club-shaped termination to the lower extremities would serve our purpose as a basis of support; indeed, the more solid and un-

yielding its character the better would it suit us; the foot, however, is not of this nature, it is composed of many segments and is capable of changing its shape so that support is given to the superstructure now in one way, now in another. It is thus essentially a kinetic mechanism, and the term "arches" applied to various parts of it is not so accurate or so significant as the term "springs."

The almost universal use of the automobile has familiarized us with the essentials of a spring. It is an arrangement whereby shocks due to inequalities in the road are minimised. If an ideal spring could be found, such shocks would be entirely eliminated. In practice the spring, as applied in the motor car, is a flexible band or bands of metal, and diminution of the shock is brought about by bending or deformation of the spring. This process of deformation takes a certain amount of time, and thus the transmitted shocks are not so sudden; again as the spring is straightened out the resistance to bending becomes gradually greater, so that the shock is met by a graduated resistance. Without entering deeply into the mechanics of springs, it will I think be evident that the value of a spring must depend on, among other things, the material of which it is made, and its length. The more flexible the material, the greater will be the power of the spring to convert a vertical impulse into a horizontal deformation; the longer it is the greater the amount of such conversion. In other words a "soft-riding" spring is flexible and long. Conversely a "hard-riding" spring is short and rigid.

One other quality is a prime necessity in a spring, viz. strength. Now, the shorter and more rigid a spring the stronger it is, the longer and more flexible it is the more readily does it break when the amount of deformation to which it is subjected is greater than it can recover from. Hence in the small car built for work over all sorts of roads, the springs are short and rigid, while in the large expensive cars, where easy riding is the main desideratum, long flexible springs are the rule. The average car builder endeavours to strike a happy medium, where a moderate amount of flexibility is combined with a considerable amount of strength. In the human foot, no such compromise has been made. Instead of that two springs have been placed side by side. On the outer side of the foot there is a short hard strong spring; on the inner side of the foot there is a long flexible spring. In the act of walking, the weight is transferred from one to the other. Again, as happens in

other machines, the long flexible spring is apt to give way when a deforming stress is applied either too great in amount or for too long a time for the spring to recover completely. This is the reason why the inner border of the foot is the weak part of the foot. It is often said that the reason why foot strain affects the inner margin of the foot is that the normal distribution of the weight of the body falls medial to a vertical line passing through the centre of the inferior surface of the os calcis. No doubt this is correct, and is applicable to the foot in its static state, but it is probably not accurate when applied to the foot in motion.

Although we speak of two springs in the foot it must be clearly understood that no suggestion is made that they are separate the one from the other with independent action. The foot is one organ not two, and the presentation of two functional springs is intended solely to emphasize the characters of the outer and inner margins respectively. Taking part in the material of each spring are bones and joints, ligaments, tendons and muscles. In both cases the point of maximum convexity of the spring is supported by a tendinous sling whose upper attachment is to the bones of the leg. In this tendinous sling, at the point of maximum strain, there is a nodule of cartilage or even a sesamoid bone.

The outer spring is made up of the following bones: os calcis, cuboid, 4th and 5th metatarsals. The joints between these bones are practically vertical. In the case of the calcaneo-cuboid joint the saddle shaped surfaces allow a small amount of gliding movement but they practically interlock. The chief ligaments concerned are the long and short plantar ligaments which extend from the under surface of the os calcis to the bases of the three middle metatarsals, forming on the way a sheath for the peroneus longus tendon. Under the cuboid, embedded in a groove in the bone, is the tendon of the peroneus longus. The abductor minimi digiti and the outer slips of the flexor brevis digitorum act as elastic chords across the arc of the spring.

The inner spring is made up of the os calcis, the scaphoid, the three cuneiforms, especially the second, and the first three metatarsals, especially the first. The part of the spring which sustains most strain is the interval between the os calcis behind, and the scaphoid in front; these bones do not normally articulate and this interval is filled by the extremely strong inferior calcaneo-scaphoid

ligament, this structure being supported in its turn by the tendon of the tibialis posticus which has frequently at this point a sesamoid nodule. The interosseous ligaments passing between scaphoid and cuneiforms and between cuneiforms and metatarsals need no special description. The abductor hallucis and the flexor tendons to the first three digits act as additional elastic supports.

The astragalus is not exactly a part of either spring. It forms the connecting link between the bones of the leg above and those of the foot below. When in walking the heel is placed on the ground the foot assumes the dorsiflexed position. This brings the widest part of the superior surface of the astragalus into the malleolar mortice, and thus adds security. In this position also the lateral anterior inferior angle of the talus engages firmly in the groove lying anterior to the posterior facet on the superior surface of the os calcis, and an articular facet may even be developed on the anterior face of this groove. In this way ample security is obtained in transmitting the weight of the body to the heel. It is noticeable that in descending a hill or in walking over hummocky ground, one instinctively dorsiflexes the foot so as to obviate the risk of sprain.

One should also not lose slight of the fact that anatomically the human foot is a very highly specialised structure, much more so than the human hand. That the foot is the more highly modified organ is easily appreciated if it be remembered that man is the only animal who walks in the erect position, and he is therefore the only animal who has an organ of locomotion specially adapted for the erect attitude. It is perhaps worth while to emphasize the fact that the capacity of the human hand for marvelously delicate work is essentially a cerebral development; there is practically no action of the hand muscles themselves that cannot be performed by the hand of the anthropoid apes. The hand of man is distinguished by the high degree of development of coordinated purposive action. (Wood Jones.) Further, it must be remembered that the human foot is in a state of active evolution. The fibular or post-axial side is tending to undergo evolutionary atrophy, and the tibial or pre-axial side is tending to undergo hypertrophy. Coincident with this, there is a shifting of the longitudinal axis of the foot to the second digit, as is evidenced by the distribution of the interosseous muscles. This fact may account for the variability of articulation between some of the bones of the tarsus, and

may be one source of difficulty for us in interpreting anatomical findings.

Let us now summarise the actual sequence of events in normal walking. The heel is brought first of all to the ground with the foot in dorsiflexion, and from there the weight is transmitted to the outer spring of the foot almost entirely. The weight is thus mainly borne by the short hard spring. Next the weight is gradually transferred across the heads of the metatarsals to the inner side of the foot. A gradual roll of small amplitude accomplishes this. The under surface of the os calcis is curved, and the fibro-fatty tissue between the bone and the skin acts as a yielding cushion. The cuboid bone is wedge-shaped, the small side of the wedge facing outwards, and the result of pressure on the outer spring must be to press this bone inward to a slight extent, thus transmitting some of the shock of impact of foot on ground to every bone of the tarsus and metatarsus. At the completion of the second stage, the foot is balanced momentarily on the tripod consisting of the os calcis posteriorly, the heads of the fifth and first metatarsals anteriorly. From this point onward all the weight is taken on the inner spring. The head of the first metatarsal sustains all the weight of the body in the take-off for the next step. The long flexible inner spring acts for the succeeding step the role of a diving board. The line of transmission of weight is along the first metatarsal shaft to the base, then through the interosseous ligament to the base of the second metatarsal which is recessed between the first and third cuneiforms, then through the second cuneiform to the central part of the scaphoid, and through it to the astragalus and so to the bones of the leg. The middle cuneiform and the central part of the scaphoid are thus the key bones of the inner spring of the foot. The middle cuneiform is buttressed on either side by the first and the third cuneiform bone and the scaphoid is similarly buttressed by the strong inferior calcaneo-scaphoid ligament below, and by the external calcaneo-scaphoid ligament on the outer side.

It may be asked what is the ultimate design of this elaborate mechanism. The reason is probably a phylogenetic one. It is of the utmost importance for the hunter pursuing his prey to preserve as clear a view of it as possible while he is in motion; equally important is it if he be in flight that movement of the head, and especially of the eyes, be reduced to a minimum. For reducing to small

dimensions the vertical movement of the head there is abundant provision in the free movement of hip joints, of knee joints and of ankle joints. The provision of a double spring in the foot itself is, however, the best possible insurance against side to side movement in walking. When the weight is borne almost entirely on the outer side of the foot, there is of necessity a lateral roll in progression of the "nautical" variety. Some observations published by Hendrix support the view that steadiness of the head is one of the essential points of progression.

Civilised man practically always uses heels to his boots in walking. Are these beneficial or harmful? If no heel be used, then it must be obvious that the first phase of the step where the heel is brought to the ground is accomplished with greater security. Dorsiflexion of the foot is more complete, and there is much less tendency to sprain the ankle. During the second phase the presence or absence of a heel makes very little difference to the individual. During the third phase the absence of the heel makes the amount of physical exertion called for excessive; it is necessary to raise the body through a greater distance than if a part of the ascent is already accomplished by the use of a heel to the boot. Again, the presence of a heel throws the line of weight of the body a shade nearer to the head of the first metatarsal which is acting as the fulcrum for the next step. Thus the force necessary to lift the weight of the body is appreciably less. In this way the use of a heel saves energy both in regard to the amount of weight to be moved and the distance through which the weight has to be moved. If heels of excessive height be used, the result is in all respects unsatisfactory. During the first phase of the step there is pronounced insecurity, especially when to excessive height of the heel there is added a very small area, frequently less than one inch square, and even this area of support is set so far forward that it provides no direct prop to the weight of the body. During the second phase when the roll of the foot is taking place and the weight is balanced momentarily on the tripod of the foot formed by the heel, the head of the fifth and the head of the first metatarsal, the high heel is pernicious because it reduces the basal area of the tripod, and substitutes for the broad secure posterior resilient platform which nature provided, a narrow, tottering, unstable perch which a shower of rain may reduce to pulp or an unguarded step may wrench from its attachment.

During the third phase of the step the high heel is equally a disadvantage for it keeps the foot in constant plantar flexion, and throws the body weight too far forward. The calf muscles are not exercised, indeed they cannot contract to advantage, for there is too much slack to be taken up before by their contraction they can do actual work in raising the heel off the ground. Their position in this respect is comparable to that of the forearm flexors when the hand is maintained in palmar flexion at the wrist joint. The maintenance of the foot in constant plantar flexion also keeps the extensor muscles on the front of the leg in a state of persistent over-stretching, and thus they too are weakened. With too high a heel the steps are of necessity short, and stumpy, a springy gait is an impossibility. Again the effort to avoid sprain of the joints of the ankle and the foot necessitates the muscles of the lower limb being kept in a condition of constant watchfulness, so that to the fact that they act at a disadvantage, there is added the fact that more is expected of them than nature designed them to accomplish.

From this consideration the fact emerges that the use of a heel on the boot involves a sacrifice of stability. But since the ground we tread is for the most part smooth, and comparatively free from obstacles, a small sacrifice of this may be made with impunity. If it be admitted that the use of a heel to the boot economises expenditure of energy in locomotion, it will be seen that the use of a heel of moderate height is a measure of practical utility. More important than the height of the heel is its area. This should always be large. For practical purposes a heel not exceeding an inch or at the most an inch and a half in height permits of active use of the calf muscles, does not excessively throw the weight forward, and yet takes off a considerable portion of the muscular strain of walking. One must bear in mind that in walking the minimum of muscular effort is made. If sufficient is called for to produce tiring of the muscles, the result will be that more and more weight will be thrown on the ligaments, the muscles themselves will be used as ligaments, and there will be consequent stretching with development of the symptoms of foot strain. This is well seen in the case of ballet dancers who are said to be for the most part flat footed. They have developed extreme flexibility of the joints of the foot, along with excessive muscular power. When necessary the arch of the foot can be formed in exaggerated degree, but when off guard

as it were, they tend to use the muscles as ligaments, and the foot is correspondingly flat.

As a further corollary, it follows that the boots used should be long enough and wide enough to give free play to the intrinsic muscles of the foot, they should be in no respect splints for the foot, and active development of the foot muscles is likely to provide the best safeguard against the painful condition known as "foot-strain."

# RECONSTRUCTIVE SURGERY OF TRAUMATIC FOOT AND ANKLE DEFORMITIES

BY ALBERTUS COTTON, BALTIMORE, M. D.

The title of this paper was chosen because of the number of traumatic deformities of the foot and ankle resulting from the great war that are presenting themselves for treatment at this time.

Before considering methods of treatment of deformities of the foot and ankle, it might be well to review their functions. The functions of the foot in order of their importance are (a) to support the body weight, (b) to give attachment to the muscles of the leg and foot, (c) to act as a lever in progression, (d) to furnish the spring movements in walking by permitting lateral and up-and-down movements. By special arrangement of the tarsal and metatarsal bones in the form of arches supported by ligaments and muscles this spring movement is obtained. The lateral movement takes place through the sub-astragaloid and medio-tarsal joints. The functions of the ankle joint are first to allow forward and backward motions of the foot upon the leg, to act as a hinge joint, and to transmit the body weight to the foot. The astragalus is the mortise bone beween the tibia above and the os calcis below, the internal and external malleolus on either side. The most important function of the foot is to support the body weight transmitted through the ankle joint. If the foot and ankle are in proper position to support the body weight painlessly, the patient will be able to stand and walk without crutch or cane. If the mobile function of the foot and ankle is lost, the patient will lose the full lever action obtained through the movement of the ankle joint and the normal elastic springy gait secured by movement of the tarsal joints. While loss of the mobile function is a great handicap, it does not prevent the patient from getting about, earning a livelihood and leading a fairly active life, providing always that a good weight bearing function is preserved.

What are the essential requisites for a good weight bearing ankle and foot? First the foot must be in proper relation to the leg—to use an automobile expression, the foot must

sition of the foot to the leg permits the body weight to be properly distributed to the heel, arch and ball of the foot and is, in the great majority of cases, the position of choice. There are some exceptions to the rule among which may be mentioned the equinus position to compensate for a short leg or after the correction of paralytic deformities of the foot (Whitman operation). Laterally the foot should be in such relation to the leg that a line drawn from the tubercle of the tibia through the center of astragalus should pass between the second and third toes when the foot is held straight up. To meet these requirements, the astragalus must be in its proper place in the mortise joint and there must not be abduction or adduction of the foot at either the sub-astragaloid or medio-tarsal joints. The longitudinal arch of the foot should be nearly normal, neither flat nor hollow. Lowering of the longitudinal arch alone does not necessarily impair the weight bearing function providing the normal weight bearing line is preserved. The painless flat foot of the negro race is a well known example to substantiate this statement. The hollow foot, however, is a much more serious handicap to weight bearing function and in well marked cases always demands treatment, either supportive or operative. The experiences of the great war have served to call the attention of the profession to the serious disabilities that can be produced by a claw foot when subject to overstrain.

Traumatic deformities of the foot and ankle which interfere with the normal function may be caused by injury or infection of the bones of the leg or ankle joint, bones and joints of the tarsus; injury or infection of the muscles or tendons; injury to nerves supplying motor function to the muscles of the leg and foot.

It would evidently be impossible to consider in detail within the limits of one paper the surgical treatment of the many deformities resulting from injury or infection of the bones and joints, muscles, tendons and nerves of the leg and foot. It is possible, however, to present a brief review of the more common types of deformity with a consideration of some of the broad general principles by which we should be guided in their treatment.

A study of these traumatic deformities shows that while the anatomical structures involved and pathology vary, the resultant deformities can be classified more or less definitely into certain types with which we, as Orthopedic surgeons, ar familiar. Gun-

shot fractures and osteomyeltis of the tibia produce bowing of the legs, anterior or lateral, often associated with varus or valgus deformities of the foot. The principles of treatment of the deformity do not differ from those governing us in the treatment of the rachitic deformities. Gunshot fractures of the ankle joint with infection of bone and joint often result in deformities similar to those produced by unreduced Pott's fracture (traumatic flat foot) with the additional factor of ankylosis of the joint. Fracture and osteomyelitis of the tarsal bones, especially the os calcis, cause a disability similar to that of rigid weak foot. The treatment of these cases is conducted along the same lines used in the treatment of traumatic and static rigid weak foot.

Destruction of the muscles and tendons with resultant scars often cause different forms of talipes. They are treated the same as we would treat acquired talipes from other causes—i. e. correct the deformity by tenotomy, fasciotomy or myotomy of shortened structures with manipulation to be followed later in suitable cases by tendon transplantation. The treatment may at times be supplemented by excision of scars, skin-grafting or plastic operations.

It is not within the scope of this paper to consider the surgical treatment of different types of injuries to nerves. Most foot deformities due to nerve injury which we see now have received surgical treatment to the nerves—rest, splinting, exploration, freeing the nerve from the scar or end-to-end suture. Irremediable injury to motor nerves of the leg and foot which has failed to respond to the various methods of treatment employed in neurological surgery results in permanent paralysis of the muscle group or groups supplied by the affected nerve. The resultant deformity is a form of paralytic talipes, the treatment of which differs very little from that of paralytic talipes produced by infantile paralysis, cerebral palsy or multiple neuritis.

## Deformities Following Fracture at the Ankle Joint.

The most common cause of traumatic weak foot is unreduced Pott's fracture. There are several types of this fracture, which if unreduced cause certain types of deformity. The most common variety is fracture of the fibula about three inches above the external malleolus, fracture of the internal malleolus with tearing of the internal lateral ligament and outward displacement of the

astragalus. This type when unreduced gives us the typical traumatic flat foot—abduction of the foot so that the center of the foot is external to the normal weight bearing line, limitation of the motions of the foot and ankle, especially of adduction and plantar flexion. This deformity gives the typical symptoms of rigid weak foot—pain on changing from a resting to an active position, weakness, lameness and stiffness. While the symptoms of these deformities of the foot are practically the same as those of rigid weak foot due to spasm or actual contracture of the peroneal tendons, the treatment must be different. Tenotomy of the peroneal tendons with wrenching and breaking up adhesions on the outer border of the foot will not cure or relieve the symptoms of this condition. It is necessary to restore the alignment of the foot to the leg, to put the foot back in gear with the leg. The astragalus must be pushed inward so that a line from the tubercle of the tibia passing through its center will pass through the space between the second and third toes. This can be brought about either by osteotomy of the tibia and fibula above the old fracture or by re-fracturing the bones at the site of the old fracture. Simple osteotomy of the tibia and fibula above the old fracture is a simple operation and is quite effective in restoring function in the majority of cases. The cosmetic effect is not all that could be desired. Re-fracturing through the site of the old fracture of the internal malleolus of the tibia and fracture of the fibula has several advantages over osteotomy. It is a more direct attack upon the deformity at the seat of the trouble. At the same time that the bones are re-fractured the adhesions about the tibio-fibular joint can be broken up and the astragalus, together with the lower fragment of the fibula, pushed inward to its normal position. After obtaining this reduction it is frequently necessary to nail the internal malleolus of the tibia in place. It is usually not necessary to use any other mechanical aid to reduction except to hold the posterior portion of the foot adducted and at a right angle to the leg while the cast is being applied. The following case illustrates the treatment by this method:

W. C., age 43, referred to the Marine Hospital by the U. S. Employees Compensation Commission.

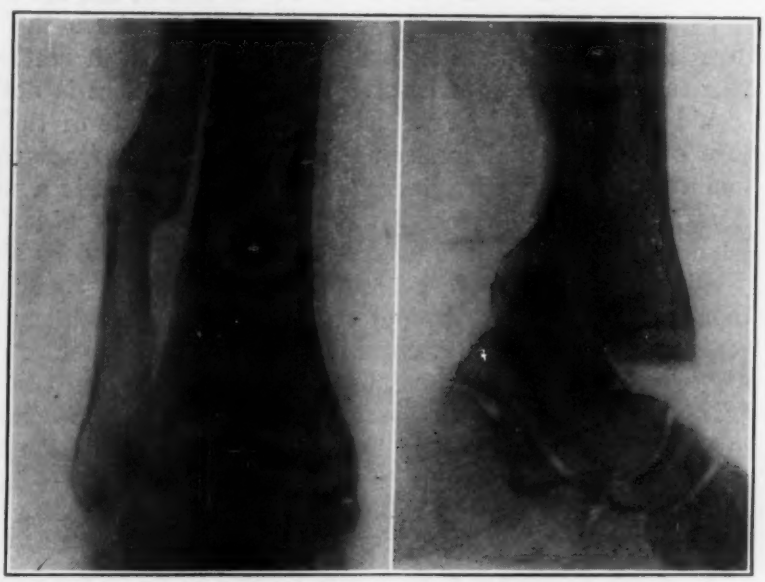
Patient sustained a Pott's fracture November 1916. Fracture unreduced on account of associated burn. Patient admitted to the Marine

Hospital May 27, 1918 suffering from symptoms of traumatic weak foot. Physical examination showed the foot held in abduction and eversion with marked limitation of adduction and plantar flexion; weight bearing line passing to inner ankle and inner side of great toe. X-ray showed unreduced Pott's fracture.

Operation June 1918: Cuneiform osteotomy of the internal malleolus at the site of fracture with linear osteotomy of the fibula fracture; incision through the tibia fibular joint; astragalus pushed inward to normal position; internal malleolus nailed; tenotomy of tendo-achillis; cast applied. Nail removed August 1918.

Examination Feb. 20, 1920: Patient walked well. The traumatic flat foot symptoms had entirely disappeared and the motions of the foot and ankle were free.

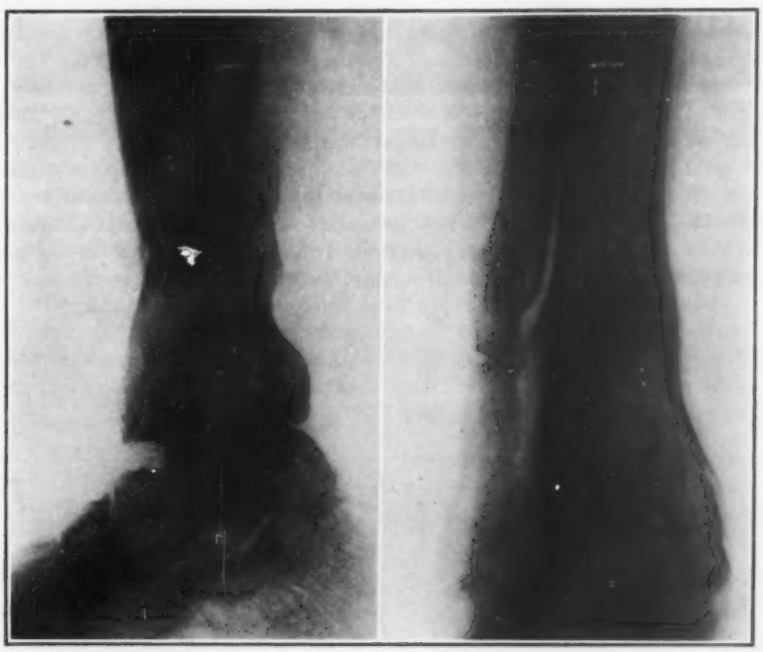
Another rarer type of Pott's fracture is fracture of the fibula, lower third, fracture of the internal malleolus with a longitudinal split of the posterior portion of the tibia extending upward from the articular surface three or four inches with posterior displacement of the astragalus. In this fracture the main portion of the lower end of the tibia is displaced forward,



CASE No. 2—W. S., before operation. Special type of Pott's fracture.

CASE No. 2—W. S., before operation. Special type of Pott's fracture with longitudinal split of tibia and forward projection of lower end of tibia.

only a small portion of its lower articular surface, including the longitudinal split, remains in contact with the upper articular surface of the astragalus. There may be also some outward displacement of the astragalus. When this fracture is un-reduced, a characteristic deformity results which differs materially from the deformity caused by the ordinary un-reduced type of Pott's



CASE No. 2—W. S., six months after operation. Operation—tenotomy of tendo-achilles; wrenching of foot; osteotomy of tibia and fibula above ankle joint; chiseling away projecting anterior portion of tibia. New ankle joint not disturbed.

CASE No. 2—W. S., six months after operation.

fracture. Many of the symptoms are quite similar but the signs are different. There is limitation of dorsal flexion due to forward projection of the lower end of the tibia and shortening of the tendo achillis. This elongates the heel. The lateral motions of the foot are definitely limited and there may be abduction of the foot. The following is an illustration of this type of deformity:

W. S., age 40. Injury to the left ankle by fall April 1917; patient walked with crutches since time of injury.

First examination made April 1919. Patient had signs and symptoms of traumatic weak foot with pain on weight bearing; foot held in abduction with marked limitation of internal and antero-posterior motions of ankle joint; limitation of lateral motions of foot especially adduction. X-ray showed fracture of the fibula, three and a half inches above external malleolus; longitudinal split of posterior portion of lower end of tibia extending into ankle joint; posterior displacement of astragalus; new joint formed by astragalus below and posterior portion of articular surface of tibia at site of fracture; greater portion of lower articular surface of tibia displaced forward; weight bearing line entirely in front of articular surface of astragalus and to inner side.

Operation April 30, 1919: Tenotomy of tendo-achillis and peroneal tendons with wrenching of the foot; cuneiform osteotomy of the tibia, internal surface and anterior border; linear osteotomy of the fibula at the same level; removal by chisel of the anterior projecting lip of the tibia; correction of the deformity and restoration of the normal alignment of the tibia and fibula anteroposteriorly and laterally; application of cast. The alignment of the fractured bones was checked up and corrected by X-ray examination. Union of tibia in eight weeks; delayed union of the fibula.

Examination Dec. 4, 1919: X-ray examination showed complete bony union of both tibia and fibula; alignment good; both anteroposterior and lateral motions of foot free and painless; considerable motion in ankle joint; patient was able to walk without cane and was well satisfied with the result.

CASE No. 3—D. F., electric wireman, before operation. T-fracture of lower end tibia with varus deformity.

CASE No. 3—D. F., after operation. Note bowing at site of osteotomy.

Another type of deformity due to unreduced fracture of the lower end of the tibia extending into the ankle joint is an acquired talipes equino-varus. The simplest method of treatment of the condition to give the patient a weight bearing foot is by tenotomy of the tendo-achillis and other resisting tendons or fascia and wrenching combined with osteotomy of the tibia and fibula above the ankle joint. This type of deformity is illustrated in the following case:

D. F., age 32, Electric Wireman.

Injury to the right ankle by fall from pole June 6, 1918; sustained a fracture of the lower end of the tibia extending into the ankle joint which was incompletely reduced.

Patient first seen Dec. 3, 1918; using crutches at that time. Physical examination showed thickening of the lower end of the tibia externally and posteriorly; external malleolus more prominent than normal; foot in position of equino-varus; dorsal-flexion limited to 135°; plantar flexion also limited; anteroposterior motions through sub-astragaloid joint; ankle joint

CASE No. 3—D. F., after operation. Operation: tenotomy of tendo-achilles and wrenching of foot; osteotomy of tibia and fibula above ankle joint. Note that upper surface of astragalus is horizontal; lateral alignment normal.

CASE No. 3—D. F., after operation. Note that entire sole of foot rests flat on ground.

ankylosed; abduction and adduction fairly free; patient walked on outer border of foot with heel drawn up. X-ray showed a T-fracture of the lower end of the tibia extending into the ankle joint; astragalus displaced forward and outward; portion of fractured tibia projecting downward in front of ankle joint.

Operation Dec. 10, 1918: Tenotomy of tendo-achillis and wrenching of the foot; linear osteotomy of the tibia and fibula above ankle joint; varus and equinus deformity corrected; foot placed at a right angle to the leg with the foot in normal alignment with the leg laterally. Bowing of the tibia with convexity backward was necessary to correct the equinus deformity. A cast was applied and the position checked up by X-ray the following day. The cast was removed in eight weeks and firm bony union found. Passive motion and massage for one month. The patient went to work April 1, 1919 and has worked continuously since that time at his occupation as electric wireman.

Examination April 1, 1920: Patient states that he has had no trouble but a very little pain in cloudy weather; walks with slight limp; some back knee to compensate for the posterior bowing of the tibia and fibula; foot a right angle to the leg with the sole of the foot flat on weight bearing; slightly more weight bearing to the outer side of the sole; lateral motions

CASE No. 3—D. F., electric wireman, before operation. T-fracture lower end tibia with varus deformity.

CASE No. 3—D. F., after operation. Note correction of varus deformity.

of the foot through the mediotarsal and subastragaloid joints; ankle joint ankylosed; dorsiflexion possible to right angle only; noticeable bowing of the tibia and fibula above ankle joint with convexity posterior. The patient states that the bowing does not interfere with use and that he can wear a boot. X-ray examination shows callus formation at site of osteotomy with posterior bowing of tibia and fibula; old T-fracture of lower end of tibia; upper surface of astragalus level.

Another common cause of deformity and prolonged disability of the foot is fracture of the os calcis. All Orthopedic surgeons are familiar with the great disability caused by old fracture of the os calcis with associated rigid weak foot. The lateral deformity of the fracture with the shortening of the tissues on the outer side of the ankle and of the peroneal tendons furnishes the pathology for the clinical condition of the rigid weak foot. The prophylactic treatment of this condition is the reduction of the fractured os calcis by manipulation, early use of passive motion and massage and furnishing the proper support to the foot when weight bearing is begun. When these principles of treatment are carried out the disabling deformity so frequently seen caused by the combination of fractured os calcis and rigid weak foot can be minimized. When the condition has developed, the treatment is practically the same as that of rigid weak foot, namely manipulation under anaesthesia with or without tenotomy of the peroneal tendons, over-correction and application of a cast. When there is a definite bony projection on the outer surface of the os calcis which impinges against the tip of the external malleolus on weight bearing or interferes mechanically with the lateral motions through the sub-astragaloid joint, operative removal is indicated. It is to be remembered that the chief cause of the disability is alteration of the normal relation of the leg to the foot together with limitation of lateral movements. If we can overcome these two conditions we can hope to obtain a good functional result in these cases. After removal of the cast proper support to the foot by shoes or plates, massage, manipulation and the baking oven must be used. The following is an illustrative case:

O. R., age 30, sent to the Marine Hospital Nov. 8, 1919, by the U. S. Employes Compensation Commission.

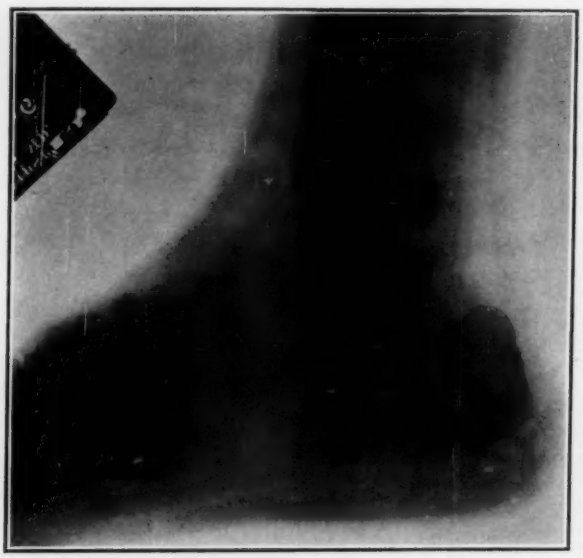
Patient fell 30 feet landing on both heels, causing fracture of both ossa calcis. X-ray examination showed fracture of the posterior portion of the right os calcis with considerable displacement of the posterior fragment;

fracture through the body of the left os calcis with external lateral displacement.

On Nov. 17, 1919 the fracture of the right os calcis was nailed; the left os calcis was moulded into position. Casts were applied to both feet. Three weeks later the casts were removed. Passive motion and the baking oven were used. On Dec. 27th, examination showed the motions good in both feet and ankles. The patient insisted upon walking and left the hospital contrary to the advice of the hospital authorities.

Re-admitted to the hospital March 20, 1920. Examination showed the right foot in good condition. The weight bearing function was excellent and the motions of the foot and ankle normal. The patient had symptoms of a stiff weak foot in the left foot with pain and tenderness under the left external malleolus, considerable bone thickening on the outer side of the os calcis below the external malleolus with marked limitation of the lateral motions especially adduction. X-ray of the right foot showed the heel fracture with the nail in position.

On April 1st the nail was removed from the right os calcis through the old incision. An incision was made over the outer side of the left os calcis



CASE No. 4—O. R., before operation. Lateral view of left foot. Note fracture of os calcis with impaction.

CASE No. 4—O. R., before operation. Antero-posterior view. Note exostosis on outer surface. Operation consisted of tenotomy of peronei longus and brevus; removal of exostosis with wrenching and correction of deformity.

and the exostosis removed from above and below the peroneal tendons. Tenotomy of the peroneal tendons above the ankle joint was done followed by manipulation. Lateral motion of the foot at the subastragaloid joint was free after removal of the exostosis and tenotomy of the peroneal tendons. The foot was placed in a plaster cast at a right angle to the leg and in moderate adduction. The cast was removed in four weeks. Two weeks later the patient walked without pain with free lateral motion in the subastragaloid joint.

## INFECTIONS.

Infectious osteomyelitis of one or both of the bones of the leg or of one or more of the tarsal bones resulting from war injuries has been shown to be a common cause of deformities of the foot and ankle. The principles used in the treatment of osteomyelitis with deformity are first the thorough operative removal of the diseased bone by the cone method with correction of the deformity by osteotomy followed by frequent cleansing of the wound and prevention of pocketing. Dr. Gallie, in his excellent article on the treatment of osteomyelitis, has shown it to be feasible to correct the deformity of long bones by osteotomy through the infected area at the time of operation for the osteomyelitis. If, however, the cases are seen after the osteomyelitis has been treated and the wound healed, the deformity should be corrected when possible by osteotomy above or below the infected area. The following case illustrates this type:

J. E. B., Marine Hospital, War Risk Ins. Case.

Shrapnel wound right tibia July 1918 resulting compound fracture of the tibia followed by osteomyelitis. There were five operations previous to his admission to the Marine Hospital.

Physical examination showed scars of the previous operations, tenderness and signs of inflammation about the middle of the anterior surface of the leg. X-ray examination showed an old fracture of the tibia with anterior and external bowing; loss of bone from the previous operations; area of rarefaction indicating bone abscess and a small sequestrium.

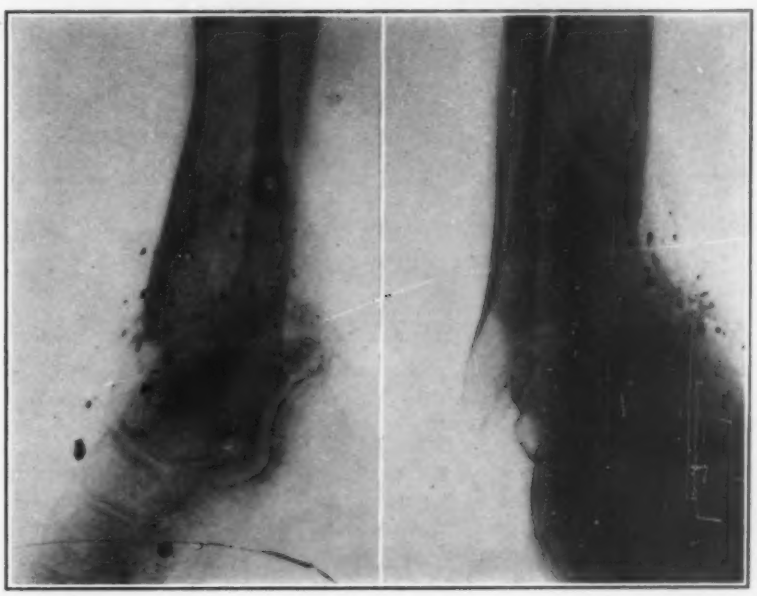
On June 4, 1919 the affected bone area was exposed by a free incision and the diseased bone thoroughly removed with a chisel leaving a cone shaped cavity. The wound was cleansed with pure carbolic and absolute alcohol and packed with iodoform gauze. Ten days later the wound was dressed for the first time. The iodoform gauze was loosened and partly removed, the wound cleansed and re-dressed. The wound was treated thereafter by daily dressings, care being taken to keep the ends of the incision open to prevent pocketing.

On February 22nd examination of the patient showed the operative wound entirely healed. There was some increase in the antero-lateral bowing of the tibia. Arrangements were made to do cuneiform osteotomy of the tibia with tenotomy of the tendo-achillis. The operation was deferred on account of an injury to the scar by a fall producing an ulcer.

CASE No. 5—J. E. B., before operation. Old fracture with osteomyelitis of the tibia. Note bone cavity inner side; callus outer side.

CASE No. 5—J. E. B., after operation. Note cone shape of operative area; healthy bone; callus formation outer side.

When the function of a muscle or a group of muscles has been lost as the result of trauma or infection and the adherent scar has produced deformity of the foot and ankle, the treatment will depend upon the amount of deformity and disability resulting and upon whether or not there has been associated injury or infection of the bones of the leg, ankle joint or tarsus. The correction of the deformity by tenotomy of the shortened tendons and the fascia and wrenching to be followed later by tendon transplantation is the usual method of treatment when the muscles only are affected. If, however, there is associated bone deformity resulting from fracture, osteomyelitis or ankylosis of the ankle joint, the problem of treatment is quite different. The bone deformity must be corrected as well as the tendon deformity and if there is ankylosis of the ankle joint, the foot must be put in proper position for weight bearing function usually at right



CASE No. 6—C. B., War Risk Insurance, before operation.

CASE No. 6—C. B., War Risk Insurance. Case, before operation. Old fracture lower end tibia extending into ankle joint; osteomyelitis; multiple foreign bodies; destruction of tendons to inner side of ankle; equino varus deformity.

angle to the leg. It may be in such cases that the loss of function of such a muscle group is unimportant and its treatment not essential to restoration of function to the foot and ankle. The following case is an example:

C. B., War Risk Ins. Case, referred from the Marine Hospital.

The patient accidentally received a gunshot wound of the lower end of the left tibia and ankle joint June 1917 resulting in a compound infected fracture of the lower end of the tibia extending into the ankle joint. The end result was destruction of the flexor tendons on the inner side of the

CASE No. 6—C. B., after operation. Note correction of equinus deformity.

CASE No. 6—C. B., after operation. Note correction of varus deformity.

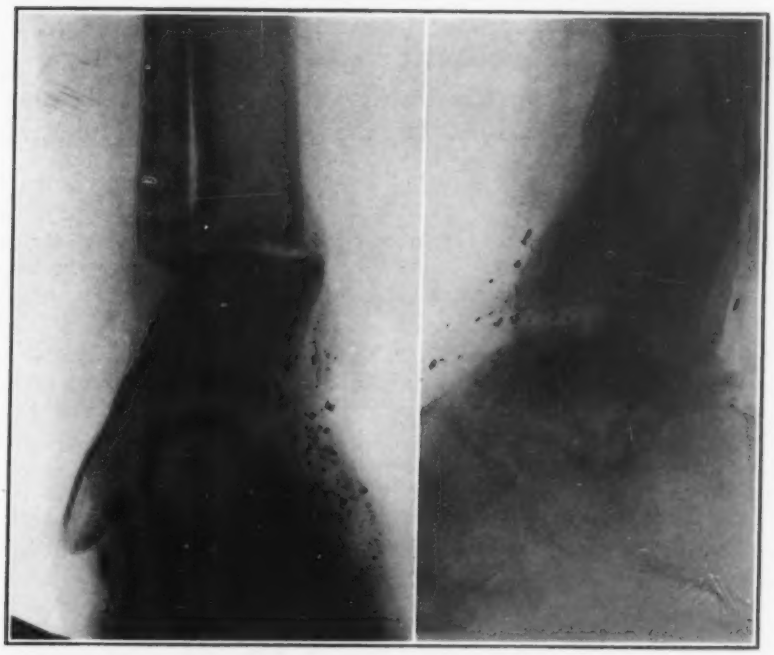
ankle joint with ankylosis of the ankle joint in a club foot position. There was complete loss of use of the flexor longus digitorum, flexor longus hallucis and tibialis posticus. There was also anaesthesia over the distribution of the posterior tibial nerve. Numerous pieces of lead were lodged in the tibia and tissues about the ankle joint. The X-ray at this time showed loss of bone on the inner side of the lower end of the tibia and internal malleolus and bony ankylosis of the ankle joint; equino-varus position of the foot; multiple foreign bodies (lead) in the bone and tissues about the ankle joint.

In Sept. 1918 the deformity was corrected. Tenotomy of the tendo-achillis was first done with wrenching of the foot. Considerable correction of the lateral deformity of the foot was possible after tenotomy and wrenching.

Osteotomy of the tibia and fibula about three inches above the ankle joint was then done. The equinus and varus deformities were easily corrected. The scar on the inner side of the ankle joint was not disturbed. It was necessary to produce a posterior bowing of the tibia and fibula at the site of the osteotomy. Care was taken to see that the varus deformity was completely corrected. After the operation a cast was applied with the foot at right angle with the leg and the lateral deformity corrected. The cast was removed in eight weeks, after which the patient was given passive motion and massage and limited use.

For a while an ankle brace with an outside ankle strap and one quarter inch "Dutchman" outer side sole and heel was used. The patient got about well with a cane.

Examination April 18, 1920: The patient walks without brace or cane. There is no sinus and the scar is in good condition. There is a scant 5° of anteroposterior motion through the subastragaloid and mediotarsal joints.



CASE No. 6—C. B., War Risk Insurance. Case, after operation. Operation—tenotomy of tendo-achilles; wrenching of foot; osteotomy of tibia and fibula above ankle joint with correction of equino-varus deformity. Note that upper surface of astragalus is horizontal; lateral alignment normal.

CASE No. 6—C. B., War Risk Insurance. Case, after operation. Note lowering at site of osteotomy and correction of equinus deformity.

The ankle joint is ankylosed at an angle of about 105°. This makes the heel about half an inch higher which compensates for the shortening due to the fracture and to bone destruction. The patient wears a shoe half an inch higher than the other with one-quarter inch "dutchman" outer side of sole and heel. There is still slight varus position of the foot and slight equinus. The posterior bowing of the tibia and fibula above the ankle joint at the site of the osteotomy can be seen on inspection of the leg. This causes the patient no inconvenience.

In this case the object of our treatment was to correct the deformity and restore weight bearing function. This was done by tenotomy and wrenching of the foot combined with osteotomy of the tibia and fibula above the old area of infected bone and scar tissue. The treatment of the scar, posterior tibial nerve and inactive flexor muscle group and the foreign bodies in and about the ankle joint was neglected altogether because it was not essential to the restoration of weight bearing function and might have led to serious trouble by starting up the old infecion.

The following is an illustration of the value of osteotomy of the tibia and fibula in restoring the weight bearing function of the foot:

G. S., age 24.

Tuberculosis of the ankle joint and os calcis with ankylosis of the ankle joint. The foot was in a position of equino-varus. The weight bearing was on the outer border of the foot and there was lameness requiring the use of crutches.

Osteotomy of the tibia and fibula above the ankle joint was done with correction of the deformity and application of a cast for eight weeks, followed by passive motion, massage and gradual use of the foot. The deformity was corrected and the patient was able to walk with the sole of the foot flat on a level surface without crutch or cane.

The following case is presented to illustrate the value of osteotomy of the tarsus in correction of old equino-varus deformities—paralytic:

D. B., Soldier, Pa., Private Patient

The patient reported for examination June 1916. The patient gave the usual history of an attack of infantile paralysis at the age of two years followed by deformity of the foot. He had been operated upon twice previously. Physical examination showed very marked atrophy of the muscles of the right leg below the knee and some atrophy of the thigh muscles. The foot was in a position of equino-varus with the head of the astragalus prominent on the outer side of the foot. There was a large callus on the outer side of the foot and an old scar on the inner side. There was marked

cavus deformity of the foot associated with equino-varus. Examination of the muscles showed paralysis of the flexor longus digitorum, flexor longus hallucis and very marked weakness of the extensor longus digitorum and peroneus longus and brevus. The tibialis anticus and posticus and the tendo-achilles and extensor longus pollucis were strong.

Operation June 15, 1916: Cuneiform osteotomy of the tarsus after method of Dr. Cook as reported at the Detroit meeting of the American Orthopedic Association in 1915. A large wedge with the base outward and extending clear through the tarsus was removed. The size of the wedge was calculated from a tracing of the X-ray of the foot. A cast was applied with the foot in the corrected position. Eight weeks later the cast was removed and the patient fitted with a brace.

In a letter received April 12, 1920, the patient states that he is doing his work as a grocery clerk which requires a great deal of standing and walking and heavy lifting. The foot does not give him any trouble. He wore the brace for nine months after the operation but since that time has discarded the brace.

CASE No. 8—D. B., before operation. Paralytic equino-varus deformity.

In the treatment of traumatic deformities of the foot our object should be to restore as good function as possible. When the object can be obtained by simple surgical procedures they should take precedence over elaborate and difficult operations. We should always bear in mind that the weight bearing function

of the foot is most important and our first object in the treatment should be restoration of this function. Having obtained our object, whether or not it is advisable to attempt restoration of other functions is a problem to be decided in each individual case. Unnecessary risks should not be undertaken and fanciful operations should be tabooed. In the first class we would place elective operations through old infected scars, bones and joints and in the second we would place arthroplasty of the ankle joint. In arrested hip joint tuberculosis in the flexed and adducted position with ankylosis most conservative orthopedic surgeons prefer to correct the deformity by subtrochanteric osteotomy and give a

CASE No. 8—D. B., after operation. Operation—Cuneiform section entirely through the tarsus; base of wedge on outer side of foot.

good weight bearing painless hip rather than by arthroplasty with the attendant danger of recurrence of the tuberculosis in the joint, tubercular meningitis or a painful joint with limited motion. Likewise in ankylosis of the ankle joint with deformity from infected joint fractures or osteomyelitis, correction of the deformity when possible by osteotomy of the tibia and fibula above the diseased area is certainly preferable to an arthroplastic operation which in addition to the danger of starting up a latent infection so rarely accomplishes the desired result. Where a cure cannot be accomplished by osteotomy a formal resection with the

object of obtaining ankylosis in a corrected position should be considered.

Of the several operative procedures to correct deformities of the foot and ankle, osteotomy is found most useful and often essential. It is used in the tarsus, either linear or cuneiform, especially to correct bad varus deformities. The greatest field of usefulness of the operation is osteotomy of the tibia and fibula above the ankle joint in ankylosis of the joint with deformity. By this operation combined with tenotomy of the shortened tendons, many deformities of the foot and ankle can be corrected and the foot placed in proper relation for restoration of the weight bearing function. In order to bring the foot to a right angle with the leg and the sole of the foot flat to a level surface it is often necessary to produce an antero-posterior bowing at the site of the osteotomy. Lateral deviation must be avoided. If the deviation from the normal anteroposterior alignment is not too great, the deformity in the shaft of the tibia and fibula will be taken care of by the application of Wolff's law—"Changes in form and function will be followed by certain definite changes in the internal architecture and other secondary alterations of their external conformation in accordance with mathematical laws." The new static condition brought about by putting the foot at a right angle with the leg and the sole of the foot parallel to a level surface will cause a gradual transformation in the bone—in the internal architecture and external contour—that in time will largely correct the deformity at the site of the osteotomy. If we, as Orthopedic surgeons, will keep constantly before us the fact that "the pathogenesis of deformity is functional" we will be better satisfied with our more or less imperfect attempts to correct deformities of the ankle and foot providing always that we correct or improve the weight bearing function. In deformities associated with ankylosis of the ankle joint we will resort less frequently to resection, astragalectomy and attempts at arthroplasty and be content to restore the weight bearing function by the simple operation of osteotomy. In none of the cases cited in this paper were the results ideal; in all, however, except two recent cases, there was sufficient restoration of function to enable the patient to walk without the aid of a cane, to get about actively and to earn a living. In conclusion I wish to emphasize the fact that each of these deformities is a separate and distinct

problem to be worked out individually. We should work out our treatment as we would solve a mathematical problem. First obtain the data, which should be a definite knowledge of the structure involved whether of the bones, muscles, joints or nerves; of the pathology whether infection or trauma or both; of the variety of deformity whether a form of talipes, deformed tibia, ankylosis of the ankle joint or a combination of several deformities. Having obtained our data, we should consider it most carefully and then apply our knowledge of the science and art of correction of deformities to the treatment of the patient. We should always bear in mind that the object of our treatment is to correct deformity and to restore function as far as possible and to accomplish this end by the simplest methods possible.

# FRACTURE OF THE FOREARM IN CHILDREN*

BY JACOB GROSSMAN, M. D.

Complete fracture at the lower end of the radius is of rare occurrence in children. Flexion or greenstick fractures of one or both bones of the forearm is the type commonly found. Classical Colles' fracture, commonly encountered in adults, is very rare in children. In our series of two hundred cases there was only one case which presented both clinically and in the X ray findings, the typical picture of Colles' fracture. (Figures 1 and 2). We did however, observe a number of subperiosteal fractures occurring at

FIGURES 1 and 2. The only case in our series of classical Colles' fracture in children.

the lower end of the radius. These cases presented themselves with a history of having fallen, striking upon the outstretched hand. Examination usually revealed slight swelling, disability and marked localized "pencil" tenderness. Ecchymosis, when present, was very slight. Crepitus, false mobility and deformity were never present. (Figure 3).

Another lesion which we found occurring at the lower end of the radius was a separation of the epiphysis. Epiphyseal separa-

*Based on the study of two hundred cases from the Orthopedic Clinic of Lebanon Hospital.

tion of the radius has always been reported as of rare occurrence. Pfaundler and Schlossmann have reported seeing two cases in a series of one thousand fractures. In our series there were thirteen cases or about six and one-half per cent of the two hundred cases. No doubt epiphyseal separation is a fairly common condition. They are readily overlooked especially when the separation is very slight and the symptoms very mild. In these instances they are usually treated as sprains or contusions. Careful X ray study

FIG. 3. CASE 3. Lateral View. Blanche G. 3 years of age. Diagnosis: Subperiosteal fracture of the radius.

will assist one in reaching a diagnosis. The separation may vary from a slight degree to a well marked one. Where there is a slight separation the symptoms are very mild. Chief amongst the symptoms are pain, localized tenderness and in very severe cases, deformity, crepitus and false mobility. The deformity was so marked in one of our cases, that it resembled the "silver fork" deformity

commonly seen in Colles' fracture in the adult. (Figures 4 and 5). The crepitus as a rule is soft and does not resemble that usually found in fractures. Three of the cases were complicated by infraction of the ulna. The symptoms resulting from the infraction were very mild.

The vast majority of the cases had sustained greenstick fractures of one or both bones of the forearm. The X ray findings in these cases were very much alike. Complete fractures of the bones were rarely present.

FIGS. 4 and 5. CASE 4. Edith S. 8 years of age. Epiphyseal separation of the lower end of the radius.

## ETIOLOGY

Of the two hundred cases, one hundred and forty-four were in males and fifty-six in females. The ages varied from thirteen months to thirteen years. There were forty-two below five years of age, ninety-five between six and ten years of age and sixty-three between eleven and thirteen. Of those below five years of age there were twenty-one of both bones, twenty-one of one bone, of which eighteen were of the radius and three of the ulna. Of those between six and ten years of age, there were fifty-two of both bones, forty-three of one bone of which thirty-eight were of the radius

and five of the ulna. Of those between eleven and thirteen years of age, there were twenty-one of both bones, forty-two of one bone of which forty were of the radius and two of the ulna.

The ages at which fractures occurred more commonly, as shown by this series, are between six and ten years, ninety-five or forty-seven and a half per cent of the cases having occurred during this period. The next most frequent occurrence was between eleven and thirteen, sixty-three or almost thirty-one and a half per cent, having occurred at those ages. Below five years of age, forty-two or twenty per cent occurred.

Between six and ten years of age both bones were more frequently fractured, fifty-two or fifty-four per cent of the cases occurring at that period, had sustained fractures of both bones. Forty-three or forty-five per cent had sustained fractures of one bone. Between eleven and thirteen years of age, one bone was more frequently fractured, forty-two or sixty-six per cent of all occurring at these ages being of one bone. Twenty-one or thirty-three and a third per cent were of both bones. Below five years of age there were twenty-one of one bone and twenty-one of both bones.

In the entire series one bone was more frequently fractured, there being one hundred and six or fifty-three per cent. Ninety-four or forty-seven per cent had sustained fractures of both bones.

In the majority of instances the fracture was the result of a fall, the patient striking either upon the outstretched hand or upon the forearm. In a number of instances there was a history of the forearm having been struck a blow, as in one case, where a swinging door striking the forearm, fractured both bones. A slight knock or a mild trauma produced fractures in a number of instances. History of former fractures was elicited in five of the cases. There were no constitutional disturbances or pathological lesions present in these cases to account for the recurrence of the fractures.

## SYMPTOMATOLOGY

Subjective: These patients were presented with a history of having sustained an injury. In a few instances, especially in the younger children and infants, the parents were not certain that an injury had occurred. Pain and restriction of function were constant symptoms. The pain was especially evident when an attempt

to manipulate the forearm was made. The disability manifested itself in what appeared to be a paralysis of the upper extremity, the latter hanging limply at the side. This was especially so in infants and the younger children. Any active movement was very painful.

Objective: Swelling, ecchymosis and deformity were present in a large number of instances. The swelling and ecchymosis were usually localized to the region of the fracture. The deformity present was angular in character, the angle being directed anteriorly as a rule. In those who had sustained a subperiosteal fracture, deformity was absent. It is this type of fracture which is commonly overlooked. The absence of crepitus, false mobility and deformity often mislead one and a diagnosis of sprain or contusion is made. Ecchymosis is not common, and when present, manifests itself as a slight discoloration. There is usually slight swelling. The characteristic objective symptom upon which a diagnosis can always be made in subperiosteal fracture is "pencil" tenderness. This tenderness is localized to the site of the fracture. It is present in all cases and persists for many weeks after the fracture had been sustained. Very little callus formation occurs during the healing of this type of fracture. This is probably due to the fracture being subperiosteal.

Fractures of the shafts of the bone were mainly of the torsion, greenstick or bending variety. False mobility was present in a large number of instances. Crepitus was elicited in a few. Tenderness was present in all the cases. It was of the "wincing" type, commonly present in bone injuries. It was usually localized to the site of the fracture.

## TREATMENT

The management of fractures in children differs considerably from that in adults. The greater intensity of the healing processes in the former requires a shorter period of immobilization. The tender skin of the infant and child, the movable cover of fat which envelops the bones, makes an exact therapy very difficult. In our experience we have found plaster of Paris bandages more efficient than splints. The affected parts can be controlled readily and accurately without the danger of pressure blebs and ulcers, the result of applying splints too tightly. We have had many cases re-

ferred to us, in which several hours after the application of splints, blebs and ulcers had appeared. Figures 6 and 7).

Another disadvantage of splints, especially in very active children, is that there is a tendency for them to fall off or become displaced. A properly applied plaster bandage will obviate these disagreeable mishaps.

Where there is a fracture of the shafts of both bones, or of the shaft of the ulna or radius alone, the deformity, should one be present, is reduced. Plaster of Paris bandages are then applied, extending from the middle of the arm to the metacarpo-phalangeal

FIG. 6. Blebs, the result of tight splints.

FIG. 7. Volkmann's contracture, the result of tight splints.

joints, leaving the fingers unconfined. The elbow is held at a right angle and the forearm midway between pronation and supination. The patient should be encouraged to exercise the fingers actively from the very first.

The plaster of Paris bandages are retained for about ten days at the termination of which time they are divided laterally, so that they can be utilized later. The limb is then removed and after being baked, passive movements of the fingers, wrist and elbow are carefully given. The limb is then replaced in the anterior posterior plaster bandages. The following day and daily thereafter the treatment as described previously is carried out. After one week of this baking and passive movements, active movements are gradually added and finally exercises. This routine is followed until the movements of the fingers, wrist and elbow are normal and

free from pain. This is usually about three to four weeks after the fracture had been sustained.

One must always bear in mind that ununited fractures of the radius are not uncommon, undoubtedly the result of improper fixation of the elbow joint, pronation and supination being insufficiently guarded against. Also that there is a tendency for the four fractured surfaces to be drawn towards one another and for union to occur with complete loss of supination and pronation. This can be avoided by fixing the forearm so that supination and pronation are impossible. Fusion of the fractured ends can be avoided by preventing all lateral pressure on the bones after proper coaptation. To be successful one must obtain proper reduction and proper immobilization. A pad between the shafts as recommended by many, is unnecessary as it could not separate the bone ends without exerting injurious pressure upon the circulation.

When the fractures occur at the lower third of the bone or bones, the plaster of Paris bandages are applied, extending from the elbow to the metacarpophalangeal joints, that is, to the knuckles behind and the transverse crease of the palm in front. The fingers should be left unconfined and the patients encouraged to move them. The forearm should be supported in a sling. The after care is the same as previously described for fractures of the upper part of the shaft.

## Case Reports

Case 1. Blanch M. seven years of age. One week before visiting the Orthopedic Clinic of Lebanon Hospital, the patient fell striking her left forearm on the pavement. As the subjective symptoms were very mild, a physician was not immediately consulted. Came to our clinic with her mother because the slight pain which she experienced still persisted. There was no disability. Chief complaint was pain referred to the upper part of the forearm.

Examination: There were slight swelling over the upper part of the forearm and very little ecchymosis in the same region. The movements of the elbow were normal. There was decided restriction of supination and pronation of the forearm. Tenderness was excruciating and localized to the junction of the middle and upper thirds of the radius. On palpation slight angulation of the deformity was perceptible, even though the deformity was not visible.

A diagnosis of fracture of the radius was made, much to the surprise of the mother, who could not understand how the bone could be broken when her child could use the forearm so freely. Proper treatment was instituted, after reduction of the deformity. The patient made an uneventful recovery, with normal supination and pronation of the forearm. (Figures 8 and 9 are X ray pictures of this case.)

FIG. 8 and 9. CASE 1. Blanche M.—Fracture of the radius.

CASE 2. Ruth F. three years of age. A few days before being referred to our clinic, the patient fell striking upon her right forearm. Immediately thereafter she had terrific pain and was unable to move the forearm. Chief complaints: pain and disability.

Examination: There was swelling which was localized to the affected region. Ecchymosis was absent. There was a slight angular deformity present. Movements of the wrist were slightly restricted. Pronation and supination of the forearm were markedly restricted and very painful. The deformity was palpable. Tenderness was excruciating and most marked about two inches above the wrist joint. Crepitus and false mobility were not ascertainable.

A diagnosis of fracture of both the radius and ulna was made and subsequent X-ray picture confirmed the diagnosis. (Figures 10 and 11.) These X ray pictures again emphasize the importance of taking more than one view of fractured bones. The antero-posterior view shows the fracture but not the deformity. The lateral view shows a well marked angulation of the fracture.

Proper treatment was instituted and the patient made an uneventful recovery.

FIGS. 10 and 11. Ruth F. Fracture of both bones of the forearm.

CASE 3. Blanche G. three years of age fell several days before coming to the Orthopedic Clinic of Lebanon Hospital. She had sustained an injury to her right forearm. The chief complaints were disability and slight pain.

Examination: There was slight swelling over the dorsum of the wrist. Ecchymosis, deformity, false mobility and crepitus were not present. There was slight restriction of the movements of the wrist. Supination and pronation of the forearm were not restricted. There was however, slight pain with extreme passive

supination and pronation. Tenderness was excruciating. It was localized to the lower end of the radius about one inch above the wrist joint. Upon this objective symptom, a diagnosis of subperiosteal fracture of the lower end of the radius was made and a subsequent X ray picture confirmed the diagnosis. (Figure 3.)

The patient made an uneventful recovery.

CASE 4. Edith S. eight years of age. A few days prior to her visit to the clinic, the patient fell from a swing and injured her right forearm. The chief complaints were pain and disability.

Examination: Swelling localized to the dorsum of the right wrist was present. There was no ecchymosis. A well marked deformity resembling the "silver fork" deformity commonly seen in Colles' fracture, was present. The hand was displaced upwards, backwards and outwards. Tenderness was present and localized to the lower end of the radius about one-half inch above the wrist joint. False mobility was present. Crepitus was also present. There also was tenderness over the styloid process of the ulna. The movements at the wrist were all restricted and passive motion produced severe pain. Pronation and supination were also restricted.

A diagnosis of fracture of the lower end of the radius and ulna was made. Subsequent X ray pictures revealed a separation of the epiphysis of the radius and a fracture of the lower end of the ulna. (Figures 4 and 5.)

The patient made an uneventful recovery.

Before concluding the writer would like to emphasize the importance of considering a fairly common lesion, when making a diagnosis of injuries of the forearm in children. This condition is called "traumatic palsy" of the forearm and is one in which a subluxation of the head of the radius occurs. Many of these patients are brought to the clinic with their forearm in splints or their wrists bandaged.

The history of how the injury was received is characteristic. The patient is either dragged along by the wrists or is raised up by the wrists. Immediately thereafter there is complete disability of one upper extremity. The limb hangs limply at the side and resembles a flaccid paralysis. Hence the name. Manipulation of the affected limb results in severe pain. The cardinal signs of fracture are lacking. The diagnosis is made by obtaining a click-

ing sound when the forearm is passively supinated. Immediately thereafter there is resumption of normal movement of the forearm. X ray pictures of this condition are negative. This is because they are X rayed after the reduction of the partial dislocation of the head of the radius. This conditon is mentioned here because many of them are treated for sprains of the wrist or fractures of the forearm.

## Summary and Conclusions

1. Where, for any length of time, infants and children refuse to use their forearms, after having sustained an injury, fracture should be suspected.

2. Colles' fracture occurs rarely in infants and children.

3. Fracture may be present, even though the cardinal signs of fracture are lacking. These fractures are usually of the subperiosteal variety. "Pencil" tenderness is the diagnostic sign.

4. Epiphyseal separation of the lower end of the radius should be looked for in all cases with injured forearm. It occurs often enough to be considered.

5. Plaster of Paris bandages are by far more efficient than splints and should be given the preference in the treatment of fractures.

6. Proper immobilization is as important as proper reduction in obtaining a successful issue in the treatment of fractures.

7. Shorter periods of immobilization, early massage and passive movements should be employed in children.

8. A pad between the shafts of the fractured bones, as recommended by many, for the purpose of preventing fusion of the fractures, is unnecessary as it could not separate the bone ends without exerting injurious pressure upon the circulation.

# THE NON-OPERATIVE TREATMENT OF SCOLIOSIS

BY WALTER TRUSLOW, M. D. BROOKLYN, N. Y.

In approaching what is perhaps the most difficult problem in Orthopedic practice, one would wish to be clear in defining the subject. This paper will deal with true rotary lateral curvature of the spine—that is, with the well-known deformity, with structural changes. Functional scoliosis must be dealt with carefully and thoroughly, but is not the bete noir that structural scoliosis is.

It is necessary also to understand just what one may expect to accomplish, and not to pre-suppose what at present seems impossible. Successful treatment of rotary lateral curvature of the spine contemplates (1) stopping the deforming process, (2) materially lessening existing deformity, and (3) reasonably assuring the non-return of the deformity. The present writer agrees with the findings of the recent Scoliosis Committee of the American Orthopedic Association, which stated that no known method had yet been found to restore to body symmetry a structural scoliosis; but he believes that the ends just outlined are worth striving for and are attainable.

Every case must be considered individually; but, in general, the non-operative treatment of structural scoliosis consists in a careful weighing of the indications for and the proper use of (1) corrective plaster-of-Paris jackets, with pressure paddings and negative window spacing, and (2) of specific intensive exercises, with retention brace or corset—often an alternating use of these means. We usually state our procedure in treating deformities, thus: "Correct the deformity first, then insure its non-recurrence." Practically, in the deformity under discussion, we find no means completely to correct the deformity, and I think that most of us agree that there is a very definite limit to the forces which we can exert on the individual patient. So it has long appeared to the writer that the one who assumes professional charge of these patients should outline a procedure which should allow the use of both means, and that he should demand for himself reasonable freedom of decision as to when either should be used. Practically, in the writer's hands an alternation of the plaster corrective jackets and of the retention-muscle training has often been most effective.

But it is insisted that the judgment of the one in charge must be formed and controlled, not only by his observation of the patient's varying general condition, but particularly by a system of measuring of the specific elements of deformity which should be reasonably accurate and yet so easily applied as to be used at each change of plaster-of-Paris jacket and at monthly intervals while the intensive exercises are being taken.

FIG. 1—The type, right-dorsal left lumbar, showing deviation of spine, low left shoulder, upper trunk-lean to the right, and bulge of right-rear chest and of left low torso.

FIG. 2—Adhesive strip placed on spine, record of deviation and of carriage of shoulders marked and relation of upper trunk-lean to plumb line shown.

(Note: In the pictures of the model, the spinous processes have been marked to show the effect of the exercises.)

After first hunting for and eliminating, if possible, unequal lengths of legs and congenital bone asymmetries, the writer finds the following elements of deformity necessary to record at regular intervals:

1. Deviation of the spine, standing.
2. Relative carriage of shoulders, standing.
3. Relation of lateral upper trunk lean to a spinal perpendicular, standing.
4. Deviation of spine, in prone lying.
5. Rotation of spine, in prone lying.

They can be recorded in from five to ten minutes, and the succeeding records, rightly studied, are exceedingly valuable. The patient stands with back exposed from neck to buttocks' fold. (Fig. 1.) A strip of adhesive plaster is placed over the spinous processes, from seventh cervical to first sacral (at top of buttocks' fold); the successive spinous processes are palpated and marked on the adhesive plaster; the level of right and left scapular

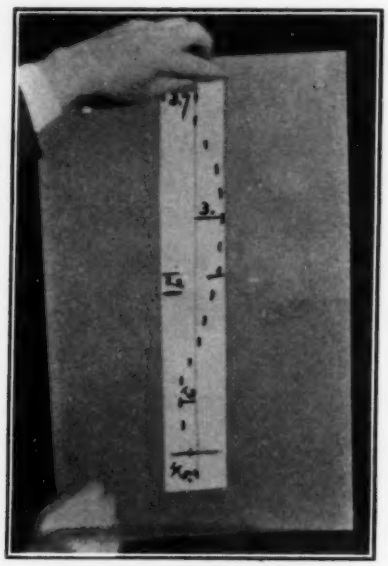


FIG. 3—Transferred adhesive strip, marking the spinous processes, the spinal height, the shoulder levels and the lateral projection of sacral perpendicular opposite seventh cervical vertebra and showing the measurements.

angles are projected and marked on the margins of the adhesive plaster. A plumb line, representing the "sacral perpendicular," is then hung in such a manner that its weight will be opposite the buttocks' fold and the upper end to right or left of the seventh cervical marking. (Fig. 2.) Where the string is opposite the seventh cervical point, a mark is made on the adhesive plaster. To make a permanent record of this, the adhesive plaster is transferred from the patient's back to any flat surface, and the following lines drawn and distances measured. (Fig. 3.) A line is drawn, with ruler

guide, from seventh cervical to first-sacral dot. It is called "spinal height." A line is drawn from it to the dot, representing greatest dorsal deviation; another to greatest lumbar deviation. Either marking, for scapular angle, is projected across the adhesive strip, to get its level relative to that of the opposite scapular angle. Measurements are taken as follows:

a. of dorsal deviation.

b. of lumbar deviation.

c. of spinal height.

d. of relative scapular levels.

e. of projection, to right or left, of seventh cervical vertebra to sacral perpendicular.

A history sheet record of the above reads, for example:

Spine, standing;

Spinal deviation $\frac{3.2 + 1.5}{45} = .1044$ or $10\frac{1}{2}\%$

Carries left shoulder 3.3 lower.

Carries 7th cervical 1.6 to the right.

The above is a record of certain elements of deformity in standing or weight-bearing posture.

To obtain a record of bony changes, weight-bearing must be eliminated. The patient is placed in a standard position prone upon a table. Another strip of adhesive plaster is used upon the exposed back from seventh cervical to buttocks' fold. Successive spinous processes, from seventh cervical to first sacral, are palpated and marked. Rotations in degree are obtained by the use of the writer's rotatometer. (Fig. 4.) This consists of two hinged arms, with a recording sector fixed to one, and an indicator fixed to the other. The arm with the fixed sector is placed across the back, at the position of greatest dorsal rotation. It takes such tilt to the horizontal as this back transverse may give it. The arm with the index has also a spirit level. This arm is moved up and down until it is levelled, and the degrees of rotation are read as at the place which its index takes on the sector of the other arm. The greatest lumbar rotation (sector arm tilted in

the opposite direction) is taken in the same way. The adhesive strip is transferred, and is ruled and measured for spinal height and for dorsal and lumbar deviations, as when taking these measurements with the patient in the standing position. The history sheet record of these measurements would read, for example:

Spine, prone;

Spinal deviation $\frac{2.2 + 1.1}{45} = .0733$ (or $7\frac{1}{3}\%$)

Rotations, 8 degrees and 5 degrees.

FIG. 4—Writer's rotatometer. Note arm to parallel the back transverse, the leveling arm and the sector and pointer.

Comparison of the relative measurements of the standing and of the prone positions, of the amount of self-correction possible and of the examiner's correction is an aid to prognosis, but is particularly important in determining how effective is the treatment, and what feature of deformity correction must be emphasized in continuing treatment.

Details of the plaster-of-Paris corrective jacket will not be dealt with at this time. Effective methods of procedure are well known. Each surgeon must use that which he knows best. But some features of technique seem worth emphasizing. First, one must have a very clear idea of the elements of deformity to be corrected. The writer finds it more effective to depend upon the application of the jacket to correct the faulty upper trunk-lean and the low shoulder, and upon the exact placing of subsequent pad-

FIG. 5—The starting position. I. Kneeling.

dings to correct the spinal deviations and the rotations; rather than to emphasize the correction of all deformity elements by the position of the patient upon which the jacket is built. To this end the hips-flexed prone lying position upon the hammock in the frame is chosen. Before plaster dressings are applied, the pelvis is fixed and then the upper trunk is stretched longitudinally and in such a manner laterally as to carry faulty upper trunk-lean across to the opposite side and to lift the low shoulder. This, of course, lessens spinal deviation and, to a slight extent, rotation; but the emphasis is placed upon the faulty upper trunk-lean and the low shoulder. Having in consideration proper counter pres-

sures, when paddings shall be used, care is taken that the transverse of the shoulders shall be in the same plane as the transverse of the pelvis. This and succeeding plaster jackets are distinctly corrective, but pressure forces are to be made quite within the limit of comfort.

Negative window spaces are cut out and first paddings to correct spinal deviation and rotation are applied in two weeks. Succeeding paddings are applied once a week to six weeks from the application of the plaster jacket. During that period the plaster rigidity itself prevents any further correction in the faulty upper trunk-lean and in the low shoulder; but much correction of the spinal deviations, of the rotation and of the anterior rib de-

FIG. 6—Exercise I. 1. To lessen spinal deviation, hollow-back, winged right shoulder and rotation, and to over correct low left shoulder and lateral trunk-lean.

formities may be obtained. The writer emphasizes this point, as he believes that hazy understanding of it accounts for indifferent success.

The appointment for the application of the second corrective jacket must allow sufficient time to take the measurements, to apply the plaster body mould (a rear half is sufficient), from which a cast is to be made for the retention brace or corset, and then to apply the second corrective jacket. The patient's position for the plaster mould for the brace cast is also hips-bend prone and with over-correction of the faulty upper trunk-lean and with levelled

shoulders. The position for the second corrective jacket is hips-bend prone with marked over-correction of the faulty upper trunk-lean and with over-correction of the low shoulder. Its program of four to six weeks is similar to that of the first corrective jacket. It has been applied in greater length, to meet natural growth plus spinal lengthening due to lessening of spinal deviation and spinal rotation. During the wearing of it, further correction of deviation and of rotation and front chest moulding will have been accomplished.

At the end of three months, the figures representing spinal deviation should have been reduced about one-half and that representing spinal height should have been slightly increased. This

FIG. 7—The starting position, II. On hands and knees.

should reduce the ratio of deviation deformity about one-half, or, for example, a ten per cent deviation deformity should be about five per cent. The upper trunk-lean, as indicated by the relation of seventh cervical vertebra to sacral perpendicular, should have been carried nearly to, or, perhaps, passing across the vertical line; and the shoulders should have been levelled. In this time it is usually possible to reduce the figures indicating rotations also about one-half. Although the correcting forces have been but gradually yet steadily applied, and although the cooler months of the year have been chosen and the "scratcher" faithfully used daily, the patient's skin and the patient's disposition will not tolerate more than three months of these jackets.

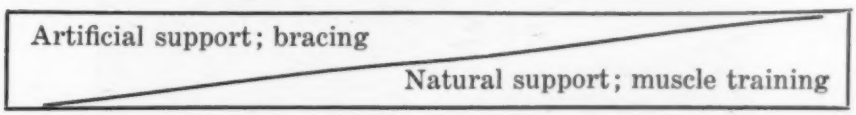
What is now to be done? We know that much of the deformity will recur if we do not hold what we have attained and so train the muscles by intensive exercises that they will increasingly be able to assume the task of natural support, with ever lessening artificial support. The brace or corset, planned for at the time of changing the plaster corrective jackets, should now be ready.

A truly retaining brace is difficult to attain, but is important. The requisites are (1) ability to hold correction attained; (2) "fool-proof"—the patient must be able to apply it with reasonable accuracy; (3) extensibility to meet normal growth, and longi-

FIG. 8—Exercise II, 1. To lessen spinal deviation and to over correct lateral trunk-lean and low shoulder. Not much effect on rotation.

tudinal extensibility and lateral compressibility to follow further deformity improvement which proper exercises will surely give; and (4) finally, if possible, self-correction. (The writer believes that this last will be possible by the use of a laterally bending upper segment of the brace and a stop-joint to prevent bending in the directions of deformity increase. The mechanical difficulties, however, are such as to make a presentation at this time of what has been accomplished premature). The Knight spinal brace can be modified to meet all of the requisites outlined, except self-correction. The brace must be worn by night as well as by day at first.

With the removal of corrective jackets and with the assumption of the retention brace, the intensive exercises begin. The brace is removed for the exercises only. The patient's back is exposed for all exercises, to observe every detail of movement. The starting positions are in kneeling, on hands and knees, in prone lying, on the back, half prone at end of table and finally sitting, to insure as little erect weight-bearing as possible and because from these positions best concentration on the parts to be exercised is obtainable. The muscles must gradually be trained to assume the responsibility of weight-bearing. As the muscles get stronger and bring the superimposed body segments nearer and nearer to the line of gravity of the body, the artificial support of the brace is less and less used. A simple reinforced corset becomes possible. The relation of artificial support to natural support may be expressed by the schematic diagram:




The exercises are classified as Preliminary and Deformity Correcting. The purpose of the preliminary exercises is:

1. To train the patient to take the starting positions and the simplest variations accurately;

2. To "limber up" the stiffened muscles and ligaments of the trunk, the shoulder girdle and the hip-joints; and

3. To start the correction of the exaggerated antero-posterior spinal curves.

All of the *preliminary exercises* are symmetrical.

I. Kneeling.
   1. With hands on hips; trunk bending forward.
   2. Alternate foot placing forward.

II. On hands and knees.
   1. Alternate head and mid-back raising.
   2. Trunk swaying forward to prone lying, then backward to resting on heels.
   3. Alternate thigh extensions backward to horizontal.
   4. Alternate arm extensions forward.

FIG. 9—Exercise II, 2. To lessen spinal deviation, to lessen winged shoulder and rotation (especially lumbar) and to lessen hollow back.

FIG. 10—Exercise II, 3. Powerfully affecting all elements of the deformity.

III. Prone lying.

1. "Seal"—with hands clasped low behind the back; raise head and shoulders and arms.

IV. Lying on back.

1. With knees drawn up (feet resting on the floor); bend both knees to the chest.

2. With arm stretched upward beyond the head; arm flinging forward, raise trunk to sitting, to forward reach to toes.

FIG. 11—Exercise III, 1. To lessen winged right shoulder and to develop right vertebro-scapular muscles. Very little effect upon lumbar deformities.

V. Half prone lying at end of table.

1. Alternate thigh raising to horizontal (knee straight).

2. Raising both thighs to horizontal (knees straight).

3. With arms stretched out at sides; raise head and shoulders and arms.

VI. Sitting.

1. With feet apart and dumbbell on floor between; raise weight floor to right shoulder, to high, to shoulder, to floor, to left shoulder, to high, to shoulder, to floor.

About a week is sufficient time to give to the preliminary exercises.

The intensive corrective exercises are progressively based on the preliminary exercises. They are asymmetrical. They aim definitely to correct the specific features of the deformity (See Fig. 1.)—the upper side trunk-lean, the low shoulder, the compound spinal deviation, the exaggerated antero-posterior curves, and especially the rotations. It is believed that this is accomplished by actively and progressively using the muscles which must be depended upon to maintain these corrections. For clearness of wording, the type—right dorsal left lumbar—is here chosen. Modifications of the following exercises must be chosen in variations from this type.

FIG. 12—Exercise IV, 2. To develop abdominal muscles (especially of the left side) and to affect all elements of the deformity.

Intensive *Corrective* (Rotation) *Exercises.*

I. Kneeling. (Fig. 5.)

1. With cane in hands; bend trunk forward to the left, reaching left side of cane far forward to the left, carrying right arm (half bent) sideways upward, with upper trunk twist to the right. (Fig. 6.)

II. On hands and knees. (Fig. 7.)

1. Stretch right thigh backward and left arm forward (synchronous movement). (Fig. 8.)

2. Place left foot forward on the floor and raise right arm sideways upward with upper trunk twist to the right (synchronous movement). (Fig. 9.) (Later).

3. Stretch right thigh far backward, sway trunk backward (to sitting on left heel), raise right arm sideways upward, twisting upper trunk to the right (synchronous movement). (Fig. 10.)

III. Prone lying.

1. With left arm forward (to the left) on the floor, head resting on left arm, and with right arm out sideways on the floor; raise right arm sideways upward with upper trunk-twist to the right. (Fig. 11.)

(Later, with increasing dumbbell weight in right hand).

IV. Lying on back.

1. With knees drawn up (feet resting on the floor); keeping knees parallel, bend toward the chest, twisting so that knees point to the right (feet to the left).

2. With arms over head on the floor; raise trunk to sitting, to left hand touch to left toe and with right arm raising sideways upward and upper trunk twist to the right (synchronous movement). (Fig. 12.)

V. Half prone lying at end of table (feet on floor). (Fig. 13.)

1. With upper trunk placed to the left on the table, left arm reaching far forward to grasp left side of table and right arm stretched out sideways; raise right thigh to horizontal (knee straight) and raise right arm sideways upward (synchronous movement). (Fig. 14.)

(Later, add increasing dumbbell weight in right hand.)

2. (Later) Repeat V. 1, but raising both thighs to horizontal (gradually getting an increasing twist to the low spine, by elevating the left hip and thigh).

VI. Left thigh support sitting on bench—"spring sitting."

1. The left thigh is supported on the bench, the right thigh-leg-foot is stretched far backward, a dumbbell is held at each shoulder; bend trunk forward to the left, reaching left arm forward (over left knee) to the floor, raise right arm sideways upward, with upper trunk twist to the right (synchronous movement). (Fig. 15.)

2. Left hand-support "spring sitting"—The left hand rests on a table far forward, the remainder of the body in spring sitting; raise right arm sideways upward with upper trunk twist to the right. (Fig. 16.)

The above exercises are planned with the least apparatus possible, so that the patient may do them at home daily. Where the operator wishes to keep entire control of all of the exercises in his own gymnasium, much elaboration will suggest itself and such apparatus as the Swedish plinth, stall bars and bom, will add to the effectiveness of much of this. The writer outlines an exercise program as follows: (1) For first month, at office gymnasium once a

FIG. 13—The starting position. V. Half prone lying at end of table.

week, (2) for second month, two office visits, (3) thereafter, once a month at office gymnasium. This is supplemented with a written gymnasium prescription (GR/) of daily home exercises, which is added to usually at each visit.

Experience has shown that these exercises are truly corrective and especially of the rotation deformity.

Now, to estimate the relative merits of the three procedures and the amount of time to be given to each:

1. The corrective plaster jacket lessens deformity more rapidly than does brace-wearing or exercises. It affects rotation least of all of the elements of deformity. It has distinct time limitation because of skin-pressure intolerance and because of the patient's attitude toward it. It must be re-assumed after a shorter interval of bracing and exercises in the paralytic spine patient.

FIG. 14—Exercise V, 1. Passively correcting low shoulder and upper trunk-lean and hollow-back, and lessening spinal deviation; actively lessening winged right-shoulder and rotation.

FIG. 15—Exercise VI, 1. Actively affecting all elements of the deformity, but especially spinal deviation and rotation.

2. The retentive brace alone will delay deformity formation. It will bring about no correction of it, and unless constantly cared for, will allow increase in deformity. It is inadequate in the paralytic spine.

3. Exercises alone will not be sufficient to prevent an increase in a deformity in which the ratio of deviation is greater than four per cent. It must be used with very gradual progression in the paralytic. When reinforced by an efficient retention brace and intermitted with an occasional short return to the corrective jacket, it is the best means available for insuring a stopping

FIG. 16—Exercise VI, 2. While passively correcting spinal deviation, low shoulder and upper trunk lean, to concentrate actively on lessening winged shoulder and rotation.

of deformity progress, for insuring a large amount of deformity lessening, and, by its general hygienic, as well as local effect, for a reasonable assurance of non-return of deformity.

As to time necessary, one would say that a structural scoliosis presenting five per cent deviation or less would require about one year of active treatment—plaster corrective jackets for three months, nine months of retentive brace and intensive supervised exercises; and that in the second year a girl could wear a

simpler reinforced corset and do her home exercises daily, with occasional supervision of the doctor. A ratio of deviation of five to ten per cent would require three months of corrective jackets; six months of retentive brace and intensive exercises; three months of corrective jackets, and a second year of bracing and supervised exercises. Greater amounts of deformity would require longer time. The paralytic, if treated non-operatively, must have a larger proportion of the time given to the corrective jacket and must be carried on for several years.

Summary:

1. Successful treatment of structural scoliosis must depend upon a clear understanding of the elements of deformity, and the lessening, if not complete elimination, of all of them.

2. Uniform and regular measurement and numerical record of the elements of deformity are important as guides to continuance of treatment and as indicating elements most needing correcion.

3. A balanced use of corrective plaster-of-Paris jackets, of retention brace and of intensive exercises is essential to satisfactory results.

4. The position of the patient when the plaster jacket is applied is responsible for improving body posture and shoulder carriage; the successive paddings, for care of the spinal deviation and the rotation.

5. Essentials of a retention brace are (a) ability to hold correction attained; (b) application by the patient with reasonable accuracy; (c) extensibility and lateral compressibility to meet normal growth and progressive deformity decrease; (d) mechanical self-correction by the brace seems possible, but not yet fully attained.

6. Gymnastic exercises must be progressive, intensive and with a minimum of erect weight-bearing. They must aim to correct all of the elements of deformity, especially that of rotation. Starting positions other than standing facilitate these ends.

7. Retention of deformity correction attained must be maintained while exercise is developing natural muscular support. Artificial support may gradually give way to natural support. The paralytic scoliotic must receive a larger proportion of artificial support than will be required for those not paralyzed in the trunk muscles. Internal splinting, by operative bone-fixation, may also be necessary in severe paralytic cases.

## MEMORIAL TO ARTHUR J. GILLETTE, M. D.

### From the University of Minnesota

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The name of Arthur J. Gillette has to be added by the Faculty of the Medical School of the University of Minnesota to the long chapter roll of its remembered and honored dead. To review the record of his life is to measure the regret of his associates that he has gone.

Success comes to many, as it came to him; but success with distinction is won, as he won it, by few. The genial nature, the kindly humor, the punctilious courtesy, the careful professionalism, like the diagnostic fingers and the analytic mind of the man, were peculiarly his own. There was a strongly personal quality in everything he did which made for the large sum of appreciation he received from his fellows.

He was essentially a son of his State. One of the pioneer students of medicine in Minnesota, he attended the Minnesota Hospital College from 1883 to 1885; he transferred his allegiance to the reorganized St. Paul Medical College in 1886; and he graduated in that year. In 1903 he took the ad eundem degree of the University of Minnesota.

In 1895 he began his notable career as a medical educator, accepting, first, an instructorship in Orthopedia; becoming a clinical professor in 1897; a full professor of orthopedic surgery in 1898; and taking charge of this Division in 1913.

In 1915 he resigned, as he said "in favor of some younger and better man." Urged by the Faculty to withdraw his resignation, he consented to continue his work but left his resignation in the hands of the School to be considered whenever the time should come to determine the limit of his usefulness. That time did not come and his resignation, still on file, has been accepted by death.

The one great ambition of his life, The Hospital for the Crippled and Deformed at Phalen Park, the first institution of its kind in America, stands as his personal and professional monument. He conceived it; he inspired the gift of the acreage upon

which it stands; he framed and promoted the legislation which created it; he superintended its construction; he directed its activities throughout its history; he determined that its staff should be of the University Faculty. A model of its kind, a noble institution of the State, an educational asset to the University, it has been, under his inspiration, more than all these,—a place of light and leadership, of human love and human service.

Service was the key-note of the life of Arthur Gillette; its one great purpose to promote the happiness of the handicapped. The smiles and the laughter of little children whose lives he lengthened, whose sufferings he assuaged, whose deformities he corrected, whose health he restored, whose usefulness and satisfaction he assured, will be his welcome in the world to which he has gone, as they were the light and the music of the world that he has left.

# AMERICAN ORTHOPEDIC ASSOCIATION

## Annual 35th Session

## Boston, Mass., June 2, 3, 4 and 6, 1921

MEETINGS HELD IN BOSTON MEDICAL LIBRARY

## PROGRAM

THURSDAY
June 2, 1921

9:00 A. M. **Presidential Address.** Dr. Robert B. Osgood.

**Lessons from My Experience with Congenital Dislocation at the Hips.** Dr. John Ridlon.

**Congenital Hip Commission Report.** Dr. Joel E. Goldthwait, Dr. Z. B. Adams, and Dr. DeForest Willard.
**Discussion** to be opened by Dr. E. H. Bradford, Dr. H. L. Taylor, Dr. H. P. H. Galloway.

**Arthroplasty.** Dr. Vittorio Putti.
**Discussion** to be opened by Dr. C. L. Starr and Dr. W. S. Baer.

**Executive Session.**

**Luncheon.**

**Bone Sarcoma.** Dr. R. B. Greenough, Dr. C. C. Simmons, Dr. W. Harmer.
**Discussion** to be opened by Dr. E. A. Codman and Dr. W. G. Stern.

**Infantile Paralysis.** Dr. R. W. Lovett.
**Discussion** to be opened by Dr. M. Hoke and Dr. A. Steindler.

**End Results in the Operative Procedures for Infantile Paralysis with Special Reference to Tendon Transplantations at the Widener Industrial Training School for Crippled Children.** Dr. A. Bruce Gill.
**Discussion** to be opened by Dr. R. T. Taylor and Dr. J. L. Porter.

**Some Views on the Immobilization Treatment of Septic Arthritis of the Knee.** Dr. F. R. Ober.
**Discussion** to be opened by Dr. W. G. Turner and Dr. R. R. Fitch.

**Unusual Destructive Lesions of the Bodies of the Vertebrae in Adults.** Dr. F. C. Kidner.
**Discussion** to be opened by Dr. P. W. Roberts and Dr. W. G. Stern.

**Myeloma of the Vertebrae.** Dr. W. G. Turner.
**Discussion** to be opened by Dr. P. W. Roberts and W. G. Stern.

**The Teaching of Orthopedic Surgery.** Dr. Nathaniel Allison.
**Discussion** to be opened by Dr. R. W. Lovett, and Dr. C. F. Painter.

EVENING SESSION—8:00 P. M.

**Ten-Minute Addresses**

**An Historical Review of Surgical Methods in the Treatment of Spine Injuries.** Dr. H. Winnett Orr.
**Discussion** to be opened by Dr. E. G. Brackett and Dr. G. W. Hawley.

**Amyotonia Congenita of Oppenheim with Case Report.** Dr. Charles A. Stone.
**Discussion** to be opened by Dr. Nathaniel Allison.

**Lengthening of the Quadriceps Tendon for Mobility of the Knee Joint—End Results and Moving Pictures.** Dr. G. E. Bennett.
**Discussion** to be opened by Dr. DeForest Willard and Dr. W. S. Baer.

**Sympathetic Segmental Disturbances, or the Association of Visceral Diseases with Minor Spinal Curvatures of the same Sympathetic Segments.** Dr. Henry Winsor.
**Discussion** to be opened by Dr. John Dane.

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FRIDAY
June 3, 1921

9:00 A. M. **Sur un nouveau traitement de la paraplegie pottique. Sur l'osteo-chondrite infantile de la hanche. (Maladie de Legg-Calve.)** Dr. Jacques Calve.
**Discussion** to be opened by Dr. F. H. Albee and Dr. F. J. Gaenslen.

**Commission Report on Ankylosing Operation on the Spine.** Dr. E. G. Brackett, Dr. J. T. Rugh, and Dr. W. S. Baer.
**Discussion** to be opened by Dr. David Silver and Dr. E. W. Ryerson.

**Army Experiences with Tendon Transferences—End Results.** Dr. Clarence L. Starr.
**Discussion** to be opened by Sir Robert Jones.

**Operative Treatment and End Results in Disabilities of the Arm and Shoulder.** Dr. Arthur Steindler.
**Discussion** to be opened by Dr. J. W. Sever and Dr. E. S. Geist.

**Arthroplasty of the Knee—Report of Cases.** Dr. W. C. Campbell.
**Discussion** to be opened by Dr. J. T. Rugh and Dr. H. L. Prince.

1:00-2:00 **Luncheon.**

**Symposium on Fractures**

2:00- **Manipulation of Stiff Joints.** Sir Robert Jones.

**End Results in Fractures of the Hip—Fracture Service of Massachusetts General Hospital.** Dr. D. F. Jones and Associates.

**End Result Fractures of the Femur.** Dr. M. S. Henderson.

**Treatment of Fractures of the Femur.** Dr. F. E. Peckham

**End Result Fractures of the Lower Leg.** Dr. E. W. Ryerson.

**Bone and Joint Fractures of the Knee and Ankle.** Dr. G. W. Hawley.

**Fractures of the Elbow in Children.** Dr. J. S. Stone.

**The Treatment of Sprain—Fracture of the Tubercle of the Tibia in Adolescence (Osgood-Schlatter Disease); Lantern Slides.** Dr. Robert E. Soule.

**Discussion** on all papers to be opened by Dr. Joel E. Goldthwaite and Dr. H. Winnet Orr.

7:00 P. M. **Dinner at Algonquin Club.**

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SATURDAY

June 4, 1921

9:00 **Peripheral Nerve Injuries.** Dr. Harry Platt.

**Discussion** to be opened by Dr. W. E. Gallie and Dr. M. S. Danforth.

**The Stabilization of Paralytic Feet. Lantern Slides.. Dr. Michael Hoke**

**Discussion** to be opened by Dr. A. B. Gill and Dr. Charlton Wallace.

**Report of Results of Cuneiform Osteotomy of the Neck of the Astragalus in Paralytic Talipes Equino Valgus, and Varus Plus Pes Cavus.** Dr. Compton Reilly.

**Discussion** to be opened by Dr. J. A. O'Reilly and Dr. M. H. Rogers.

**Congenital Club Feet (General and Present Methods in the Treatment of).** Dr. Eben W. Fiske.

**Discussion** to be opened by Dr. A. H. Freiberg and Dr. F. R. Ober.

**A Clinical and Experimental Study of the Application of Free Transplants of Fascia and Tendon in Orthopedic Surgery.** Dr. W. E. Gallie and Dr. A. B. LeMesurier.

**Discussion** to be opened by Dr. David Silver and Dr. W. W. Plummer.

**Commission on Stabilizing Operations Upon the Foot.** Dr. A. G. Cook, Dr. R. R. Fitch, and Dr. W. G. Stern.

**Discussion** to be opened by Dr. DeForest Willard.

12:00 **Executive Session.**

P. M. **Canton.** Massachusetts Hospital School for Crippled and Deformed Children.

## TO BE READ BY TITLE

**The Pathology of Two Unusual Cases of Contracture.** Dr. Sydney M. Cone.

**A Report of Three Cases of Avulsion or Fracture of the Lesser Trochanter.** Dr. C. F. Eikenbary.

**The Control of the Anterior Arch in Selected Cases of Morton's Toe.** Dr. Roland C. Meisenbach.

**Certain Inconsistent Deductions from the Surgery of the Great War.** Dr. Fred H. Albee.

**The Treatment of Caries of the Spine. Methods of Recording Scoliosis. Studies in Spinal Side Flexibility and Congenital Dislocation of the Hip.** Dr. E. H. Bradford.

**An X-ray and Anatomical Study of the Lumbo-Sacral Region.** Dr. J. A. O'Reilly.

**An Operation for the Treatment of Severe Acetabular Disease. Fracture Reduction with the Aid of a Simple Traction Apparatus. Pulmonary Edema Following Pott's Disease.** Dr. Robert Soutter.

**Reconstruction of the Internal Lateral Ligament of the Knee Joint.** Dr. John C. Wilson.

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## MONDAY

**June 6, 1921**

**Clinical Day**

**Building E. Harvard Medical School**

9:00 Sir Robert Jones. Diagnostic Clinic.

Dr. Vittorio Putti. Diagnostic Clinic.

Dr. M. N. Smith-Petersen. Arthrodesis Sacro-Iliac Joint; A New Method of Approach.

Dr. R. B. Osgood. Radio-Humeral Bursitis.

Dr. Hat. Stoeffel Operation on Adults.

Dr. Vitterio Putti. Arthroplasty of Knee Joint Operation on Cadaver.

Dr. W. R. MacAusland. Arthroplasty of the Elbow. Moving Pictures.

Dr. J. D. Adams. A Series of Claw-foot Cases Showing the Results of Jones Operation.

Sir Robert Jones. Operation on Cadaver.

1:00- 2:00 Luncheon.

Anatomical Demonstration to be held in Building B, Harvard Medical School

**Monday, June 6th, 1921**

**2 O'clock**

**Harvard Medical School, Building E.**

| | Time |
|---|---|
| **Frame for Fasciotomy**—Dr. S. F. Stewart | 5 |
| **Shell, lid, and arm piece**—Dr. R. P. Schwartz & Dr. Li | 10 |
| **Plaster cuirass**—Dr. Robert Soutter | 10 |
| **New apparatus for congenital hip**—Dr. E. H. Bradford | 10 |
| **Lantern Slides of bone affections**—Dr. Robert W. Lovett | 20 |
| **End Results**—flattened head of the femur—Dr. Arthur T. Legg | 10 |
| **Pathological aspect of human and bovine tuberculosis**—Professor S. B. Wolbach | 15 |
| **Milk and tuberculosis**—Professor M. J. Rosenau | 15 |
| **Surgical aspects of milk borne tuberculosis**—Sir Robert Jones | 10 |

**Anatomical Operative Demonstrations**

**Building B, 4 O'clock**

| | |
|---|---|
| **Fasciotomy**—Dr. Robert Soutter | 10 |
| **Obstetrical paralysis**—Dr. James Warren Sever | 10 |
| **Fascia transplantation**—Dr. Arthur T. Legg | 10 |
| **Club Foot**—Dr. Frank R. Ober | 10 |
| **Decompression in spastic paralysis**—Dr. Harvey Cushing | 15 |

# News Notes

There was recently formed in Los Angeles and vicinity an organization known as the Los Angeles Orthopedic Society.

The society plans to hold five regular meetings yearly as follows: the second Monday of January, March, May, September and November.

The first regular meeting was held at the Los Angeles City Club, March 14, 1921, at which there was a dinner followed by the election of officers and a scientific program. The officers elected were as follows:

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|---|---|
| W. W. Richardson, M. D. | President |
| C. L. Lowman, M. D. | Vice President |
| Alfred E. Gallant, M. D. | Secretary-Treasurer |

The roster of membership included the following:

| Name | City |
|---|---|
| Chappel, H. W. | Los Angeles |
| Dunlop, John | Los Angeles |
| Gallant, Alfred E. | Los Angeles |
| Hart, Trusten | Los Angeles |
| Koebig, Walter E. | Los Angeles |
| Lowman, C. L. | Los Angeles |
| Lokrunz, Sven. | Los Angeles |
| Pyles, Richard H. | Los Angeles |
| Reed, E. N. | Los Angeles |
| Richardson, W. W. | Los Angeles |
| Rue, Homer | Los Angeles |
| Spiers, H. W. | Los Angeles |
| Wilson, John C. | Los Angeles |
| Young, Chas. S. | Los Angeles |
| Los Angeles vicinity: | |
| Clark, William Arthur | Pasadena |
| Brown, Scott J. | Long Beach |
| Galvin, A. H. | Anaheim |

The program for the first regular meeting was as follows:

1. Surgical Importance of Torsion Deformities (with lantern slides) by C. L. Lowman, M. D.

2. Symposium of the literature on Astragalectomies, by H. W. Chappel, M. D.

Both papers were interesting and evoked considerable discussion.

Two men who have long been prominent in Orthopedic work, Joseph Kurtz, M. D., of Los Angeles, and John P. Lord, M. D., of Omaha, Neb., were made honorary members of the society.

The next regular meeting will be held the second Monday in May, at which time the society hopes to have the members of the Pacific Coast Orthopedic Society as its guests.

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Announcement has been received of the formation of the Lexington Clinic at 190 No. Upper Street, Lexington, Kentucky. Dr. C. C. Garr is the Orthopedic Surgeon associated with the Clinic.

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Dr. Joseph M. Spellissy of Philadelphia who was seriously injured in a motor accident some months ago has now nearly recovered. He sustained a fractured femur and other injuries. Dr. James K. Young writes that during Dr. Spellissy's confinement to the hospital he devised a very ingenious lifting apparatus.

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The New York Orthopaedic Hospital and Dispensary has received $25,000.00 by the will of Mrs. Elizabeth Southmayed, who died in New York City March 31.

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Dr. Wallace Blanchard has resigned, after 27 years of service, from the Clinic at The Hospital for Destitute Crippled Children, Chicago. Dr. E. J. Berkheiser, who has been associated with Dr. Ridlon, will have charge of the Clinic on Tuesday and Friday.

# Orthopaedic Titles in Current Literature

Prepared by Dr. J. E. M. Thomson, Lincoln, Nebraska.

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**Axhausen, G.** The formation of Joint Bodies. Arch. F. klin. Chir., 1920, CXIV, p. 1.

**Bidou, Grabriel.** Paris. Instrumental Orthopedics. Jan. 21, 1921, 45, No. 2, p. 35.

**Blanco, Pio.** Giant-Cell Tumor in the Knee Joint; Report of a Case. J. of Orthopaedic Surg., April, 1921, Vol. 3, No. 4, p. 156.

**Bloodgood, J. C.** Bone Tumors; Myxoma, Central and Periosteal. Ann. Surg., 1920, LXXII, p. 712.

**Boerner, E.** Luxatio Pedis Sub Talo. Deutsche Zeitschrift fur Chirurgie, Leipzig, Feb., 1921, 161, No. 1-2, p. 135.

**Bosch, Arana, G.** Osteosarcomata of the Radius Treated by Resection and Fibular Grafts. Semana med., 1920, XXVII, p. 801.

**Bradford, E. H.** Flat-Foot: a Simple Method of Treatment. Internat. J. Surg., 1920, XVIII, p. 143.

**Bruning.** Treatment of Rachitic Curvatures. Deutsche Medizinische Wochenschrift, Berlin, Dec. 28, 1920, 46, No. 52, p. 1437.

**Beresford, G. W.** Ununited Fractures. Brit. Med. J. Mar. 26, 1921, 1, No. 3, p. 456.

**Chelmonski, A.** Alimentary Disease of Bone. Presse Medicale, Paris, Feb. 9, 1921, 29, No. 12, p. 115.

**Clark, William Arthur.** A Protractor for Measuring Rotation of Joints. J. of Orthopaedic Surg., April, 1921, Vol. 3, No. 4, p. 154.

**Cohn, M.** Kineplastic Operations in Italy. Muenchen. med. Wchnschr., 1920, LXVII, p. 1024.

**Cooke, G. Carlyle.** A New Splint for Treating Fractures of the Long Bones. J. A. M. A., April 23, 1921, Vol. 76, No. 17, p. 1162.

**Cooperman, M. B.** Stave Fracture of First Metatarsal Bone. Annals of Surgery, Feb., 1921, 73, No. 2, p. 215.

**Collins, A. W.** Fracture Reduction and Fixation with a Specially Designed Band. Archives of Surgery, Mar., 1921, 2, No. 2, p. 354.

**Cramer.** Snapping Hip. Ztschr. f. aerztl., 1920, XVII, p. 525.

**David, V. C.** The Treatment of Acute Suppurative Arthritis of the Knee Joint. Surg. Clin., Chicago, 1920, IV, p. 1253.

**Debrunner, H.** The Function of the Abductor Hallucis Muscle and Its Relation to Hallux Valgus and Flat-Foot. Arch. f. Orthop., 1920, XVIII, p. 143.

**DeGaetano, L., and S. Scigiano.** Pyogenic Osteomyelitis Chronic for Forty-three Years. Riforma Med., 1920, XXXVI, p. 757.

**Dejerine, (Mme.) and A. Ceillier.** Para-Osteo-Arthropathy Medicine, Paris. Feb., 1921, 2, No. 5, p. 363.

**Dickson, J. A.** Treatment of Stiff Metacarpophalangeal Joints Where There Is no Gross Bony Alteration. Jan., 1921, 8, No. 31, p. 272.

**Dollinger, B.** Congenital Luxation of Both Radii. Orvosi hetil., 1920, LXIV, p. 349.

**Dubs, J.** Isolated Dislocation of the Humeroradial Articulation and Epicondylitis. Schweiz. Med. Wchnschr., 1920, 1, p. 778.

**Edwards, A. H.** Operative Procedure for Repair of Collateral Ligaments of Knee-Joint. British J. of Surg., Jan., 1921, 8, No. 31, p. 266.

**Ewing, D. A.** Dislocation of Carpal Scaphoid. J. A. M. A., April 16, 1921, Vol. 76, No. 16, p. 1078.

**Fischer, A. E.** The Treatment of Fistulae Following Gunshot Injuries of the Bones and Osteomyelitis. Zentralbl. f. Chir., 1920, XLVII, p. 1167.

**Giannuli, F.** Pseudo-Syringomyelia and Chronic Poliomyelitis. Policlin., Roma, 1920, XXCII, sez, med., p. 441.

**Goeldel, W.** The Causation and Treatment of Epicondylitis. Muenchen. med. Wchnschr., 1920, LXVII, 1147.

**Goldstein, M.** Hand-Forearm Reflex and First Phalanx Reflex. Dec. 17, 1920, 77, No. 51, p. 1460.

**Gorsch, R. V.** Compression Fracture of First Lumbar Vertebra with Delayed Symptoms (Kuemmel's Disease). Annals of Surgery, Mar., 1921, 123, No. 3, p. 360.

**Hare, D. C., and C. C. Bernard.** Case of Osteitis Deformans. Feb. 19, 1921, 1, No. 5086, p. 37.

**Henderson, M. S.** Old Fractures. n. Lancet, 1920, n. s., XL., p. 687.

**Heueman, G.** Spinal Disease as a Condition Responsible for Lumbago and Sciatica. Svenska laekartidningen, 1920, XXVII, sez. med., p. 441.

**Howard, W. P.** Fracture of the Tarsal Scaphoid With Dorsal Dislocation of the Lower Fragment. Albany M. Ann., 1920, XLI, p. 406.

**Jacobs, O., and G. Worms.** Traumatic Injury of Semilunar Cartilage of Knee. Revue de Chirurgie, Paris, 1920, 39, No. 9-10, p. 529.

**Jastram, M.** A Contribution to the Genesis and Structure of the Ganglia of the Knee Joint. Deutsche Ztschr., f., Chir., 1920, CLVII, p. 145.

**Kanavel, A. B.** The After-Treatment of Infections of the Hand. Surg., Clin., Chicago, 1920, IV, p. 1165.

**Kaufmann, C.** Dislocation of the Humeroradial and Radio-ulnar Articulations and Its Relation to so-called Epicondylitis. Schweiz. med. Wchnschr., 1920, I, p. 665.

**Kleinberg, Samuel.** Scoliosis. Surg., Gynec. and Obstet., April, 1921, Vol. XXXII, No. 4, p. 364.

**Levy, R.** The Etiology of Osteochondritis Deformans Coxae. Zentralbl. f. Chir., 1920, XLVII, 1338.

**Loeffler, F.** The Route of Tuberculous Burrowing Abscesses on the Basis of Anatomical, Clinical, Roentgenological and Pathologic—Anatomical Investigations. Ztschr. f. orthop. Chir., 1920, XL, 26, p. 97.

**Lorenz, A.** The Treatment of Recent and Old Fractures of the Neck of the Femur. Med. Klin., 1920, XVI, 869, p. 896.

**Lord, J. P.** The Cause of Failure After Operations for Club-Feet. Neb. State Med. J., May, 1921, Vol. VI, No. 5, p. 129.

**Luccarelli, V.** Decompressive Operation with Fracture. Archivio Italiano di Chirurgia, Bologna, Mar. 5, 1920, 3, No. 1-2, p. 165.

**Manuwald, A.** Ossifying Myositis. Deutsche Zeitschrift fur Chirurgie, Leipzig, Feb., 1921, 161, No. 1-2, p. 39.

**Marshall, H. W.** When to Open Knee-Joints. Boston Med. and Surg., J. Mar., 24, 1921, 184, No. 12, p. 291.

**Miller, E. M., and B. E. Bonar.** Effect of Phosphorus in Rickets. J. A. M. A., Mar. 26, 1921, Vol. 76, No. 13, p. 850.

**Moore, W. C.** Suture of Peripheral Nerves. Indiana State Med. Assn. J., Jan. 15, 1920, 14, No. 1, p. 11.

**Montgomery, A. H.** Bone Cysts. Surg. Clin., Chicago, 1920, IV, p. 1287.

**Moodie, R. L.** The Amputation of Fingers Among Ancient and Modern Primitive Peoples and Other Voluntary Mutilations Indicating Some Knowledge of Surgery. Surg. Clin., Chicago, 1920, IV, p. 1299.

**Morgan, I., and A. T. Roberts.** Endothelioma of the Cauda Equina. Med. J. Australia, 1920, II, p. 533.

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**Nigst, P. F.** Treatment of Fracture of Tibia. Scweizerische medizinische Wochenschrift, Basel, Jan. 27, 1921, 51, No. 4, p. 79.

**Nordman, O.** The Treatment of the Neuropathic Ulcer of the Foot With Transplantation of Sensory Nerves. Med. Klin., 1920, XVI, p. 797.

**Phemister, D. B.** Operation for Epiphysitis of Head of Femur (Perthes' Diseases). Archives of Surgery, Mar., 1921, 2, No. 2, p. 221.

**Pike, H. V.** Indications for Spinal Drainage in Certain Mental Diseases: Preliminary Report of Manometric Readings, with the Results of Treatment in 25 Cases. J. A. M. A., 1920, LXXV, p. 1562.

**Pirtle, R. T.** Case of Fractured Hip in Patient Aged One Hundred and Six Years. Kentucky Med. J., Mar., 1921, 19, No. 3, p. 115.

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**Robert, A. E.** The Treatment of Diaphyseal Leg Fractures by Encircling the Tibia According to the Putti-Parham Method. Rev. med. de la Suisse Rom., 1920, XL, p. 782.

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**Schlesinger, E.** Curvature of the Spine. Archiv fur Kinderheilkunde, Stuttgart, Dec. 28, 1920, 68, No. 4-5, p. 342.

**Schwarzmann, E.** The Operative Treatment of Hallux Valgus. Med. Klin., 1920, XVI, p. 905.

**Sheehan, J. E.** A Case of Leontiasis Ossea. Med. Record, 1920, XCVIII, p. 1017.

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**Sorrel, E.** Tuberculous Bone and Joint Disease. Presse Medicale, Paris, Feb. 5, 1921, 29, No. 11, p. 101.

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**Stephens, Richmond.** Osteomyelitis Following War Injuries. J. of Orthopaedic Surg., April 1921, Vol. 3, No. 4, p. 138.

**Stern, Walter G.** Chronic Circumscribed Osteomyelitis. J. of Orthopaedic Surg., April 1921, Vol. 3, No. 4, p. 132.

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